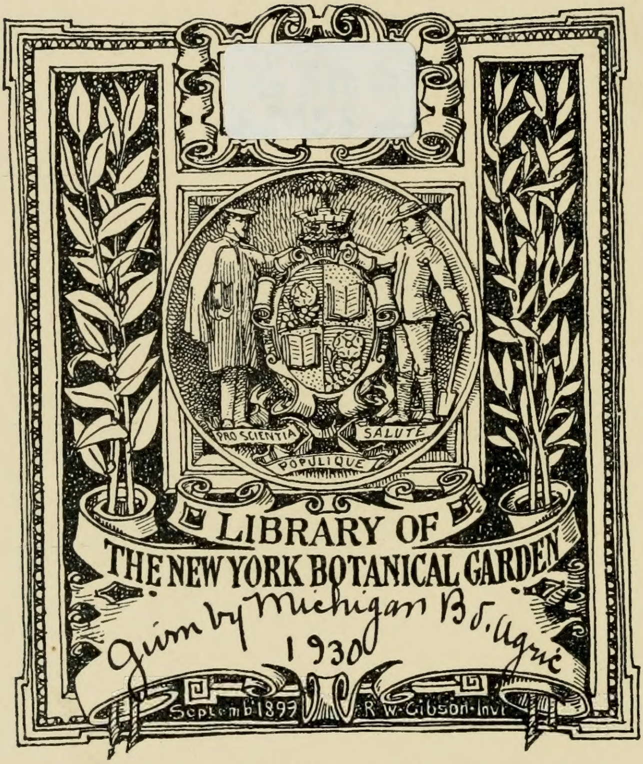


Given by Michigan Bd. Agric.
1930

SIXTY-SECOND ANNUAL REPORT

OF THE

SECRETARY

OF THE

State Board of Agriculture

OF THE

STATE OF MICHIGAN

AND

THIRTY-SIXTH ANNUAL REPORT

OF THE

EXPERIMENT STATION

FROM

JULY 1, 1922, TO JUNE 30, 1923

LIBRARY
NEW YORK
BOTANICAL
GARDEN.

BY AUTHORITY

LANSING, MICHIGAN
1924

.N7772
v. 62

REPORT OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

East Lansing, Mich., *July 1, 1923.*

To Hon. Alex. J. Groesbeck,

Governor of the State of Michigan:

Sir—I have the honor to submit to you herewith, as required by law, the accompanying report for the fiscal year ending June 30, 1923, with supplementary papers.

Very respectfully,
HERMAN H. HALLADAY,
Secretary of the State Board of Agriculture.

STATE BOARD OF AGRICULTURE

	Term Expires.
L. WHITNEY WATKINS, Manchester Chairman of the Board.	1st Monday January, 1926.
JASON WOODMAN, Paw Paw	1st Monday January, 1924.
CLARK L. BRODY, Lansing	1st Monday January, 1924.
MRS. DORA STOCKMAN, Lansing	1st Monday January, 1926.
MELVILLE B. McPHERSON, Lowell	1st Monday January, 1928.
JAY R. McCOLL, Detroit	1st Monday January, 1928.
*DAVID FRIDAY, President of the College	Ex-Officio.
—ROBERT S. SHAW, B. S. A., Acting President	Ex-Officio.
HERMAN H. HALLADAY, Secretary.	
JACOB SCHEPERS, Treasurer.	

---

*Resigned June 1st, 1923.
–Appointed Acting President June 1, 1923.

LIBRARY
NEW YORK
BOTANICAL
GARDEN

GENERAL ADMINISTRATIVE OFFICERS

OFFICE OF THE PRESIDENT.

[3]David Friday, President.
[1]Robert Sidey Shaw, Acting President.

OFFICE OF THE SECRETARY.

Herman H. Halladay, Secretary.
Jacob Schepers, Treasurer.
Nellie Campbell, Assistant Cashier and Bookkeeper.
Willard Nicholas Sweeney, Purchasing Agent.
[2]Maude Adele Meech, Chief Clerk.

OFFICE OF REGISTRAR.

Elida Yakeley, Registrar.
Anna Louise Ferle, Assistant Registrar.

DIVISION OF AGRICULTURE.

Robert Sidey Shaw, B. S. A., D. Agr. Dean; Director of Experiment Station.
Elton Brainard Hill, B. S., M. Agr. Assistant to Dean and Director; Director of Short Courses.

DIVISION OF ENGINEERING.

George Welton Bissell, M. E., Dean.

DIVISION OF HOME ECONOMICS.

Louise Hathway Campbell, B. S., Acting Dean of Home Economics.
Maude Cushman Thompson, Social Director.

DIVISION OF VETERINARY MEDICINE.

Frank Wilbut Chamberlain, B. S., D. V. M., Acting Dean of Veterinary Medicine.

DIVISION OF APPLIED SCIENCE.

Frank Stewart Kedzie, D. Sc., Dean.

NOV 12 1930

---

[1]Appointed June 1, 1923.
[2]Resigned May 18, 1923.
[3]Resigned June 1, 1923.

DIVISION OF EXTENSION.

Robert James Baldwin, B. S., Director.
Karl H. McDonel, B. S., Assistant to Director.

SUMMER SESSION.

Edward Hildreth Ryder, M. A., M. Ped., Director.

LIBRARY.

Linda Eoline Landon, Librarian.
Cora Lucinda Feldkamp, B. S., Reference Librarian.
Ruth Rogers McKinley, B. S., Library Assistant.
LeRoy C. Stegeman, Library Assistant.

M. A. C. ASSOCIATION.

Robert John McCarthy, B. S., Secretary; Alumni Recorder.

OFFICERS OF INSTRUCTION

[1,2]DAVID FRIDAY, A. B. President.
[1]ROBERT SIDEY SHAW, Acting President.

DEANS.

[2]ROBERT SIDEY SHAW, B. S. A., D. Agr.; Acting President; Dean of Agriculture; Director of Experiment Station.
GEORGE WELTON BISSELL, M. E., Dean of Engineering.
FRANK WILBUT CHAMBERLAIN, B. S., D. V. M., Acting Dean of Veterinary Medicine.
LOUISE HATHWAY CAMPBELL, B. S., Acting Dean of Home Economics.
FRANK STEWART KEDZIE, D. Sc., Dean of Applied Science.

PROFESSORS.

WILLIAM JAMES BEAL, Ph. D., D. Sc., D. Agr., Professor of Botany, Emeritus.
HERMAN KLOCK VEDDER, C. E., Professor of Civil Engineering.
*WALTER BRADFORD BARROWS, S. B., Professor of Zoology and Physiology; Curator of General Museum.
ARTHUR RODNEY SAWYER, B. S., E. E., Professor of Electrical Engineering.
WILBUR OLIN HEDRICK, Ph. D., Professor of Economics.
RUFUS HIRAM PETTIT, B. S., in Agr., Professor of Entomology.
WALTER HIRAM FRENCH, M. Ped., M. S., Professor of Agricultural Education; Director of Vocational Teacher Training.
ERNEST ATHEARN BESSEY, Ph. D., Professor of Botany.
WILLIAM WALTER JOHNSTON, A. M., Professor of English Literature and Modern Languages.
LOUIS CLARK PLANT, M. S., Professor of Mathematics.
MERRIS MICKEY MC COOL, Ph. D., Professor of Soils.
ALFRED KNIGHT CHITTENDEN, M. F., Professor of Forestry.
WARD GILTNER, D. V. M., M. S., Professor of Bacteriology and Hygiene.
EDWARD HILDRETH RYDER, M. A., M. Ped., Professor of History and Political Science; Secretary of the Faculty; Director of Summer Session.
ROBERT KENT STEWARD, B. S., C. E., Professor of Drawing and Design.
ARTHUR JOHN CLARK, A. B., Professor of Chemistry.
CHARLES WILLIS CHAPMAN, A. .B,, B. S., Professor of Physics.
CHARLES PARKER HALLIGAN, B. S., Professor of Landscape Gardening.
GEORGE ARTHUR BROWN, B. S., Professor of Animal Husbandry.
HARRY HAYES MUSSELMAN, B. S., Professor of Farm Mechanics.

---

*Died February 26, 1923.

Joseph Frank Cox, B. S., Professor of Farm Crops.
Henry Bernhard Dirks, B. S., M. E., Professor of Mechanical Engineering.
John Siebert Taylor, Director of Music.
Ollie Ezekiel Reed, M. S., Professor of Dairy Husbandry.
Victor Ray Gardner, M. S., Professor of Horticulture.
[1]Albert Milton Barron, B. S., Acting Director of Physical Education.
Lt. Colonel Thomas Lilly Sherburne, B. S., Commandant, Military Department.

ASSOCIATE PROFESSORS.

Richard deZeeuw, Ph. D., Associate Professor of Botany.
Ralph Chase Huston, Ph. D., Associate Professor of Chemistry.
Elam Tandy Hallman, D. V. M., Associate Professor of Animal Pathology.
Chace Newman, Associate Professor of Drawing and Design.
Lloyd Clement Emmons, A. M., Associate Professor of Mathematics.
John Peter Hutton, D. V. M., Associate Professor of Surgery and Medicine.
Lawrence North Field, B. M. E., Associate Professor of Drawing and Design.
George Herbert Coons, Ph. D., Associate Professor of Botany.
Egbert Sylvester King, B. L., Associate Professor of Public Speaking.
Charles Scott Dunford, M. A., Associate Professor of Economics.
Merton Maine Cory, E. E., Associate Professor of Electrical Engineering.
Charles Ernest Millar, Ph. D., Associate Professor of Soils.
William Earl Laycock, A. B., Associate Professor of Chemistry.
Harry Septa Reed, B. S., Associate Professor of Chemistry.
Benjamin Brokaw Roseboom, B. S., Associate Professor of Physiology.
Bruce Edwin Hartsuch, A. B., Associate Professor of Chemistry.
[11]Ozias Talcott Goodwin, B. S., Associate Professor of Dairy Manufactures.
Winifred Sarah Gettemy, Associate Professor of Home Economics.
Allen Clifton Conger, B. S., M. A., Associate Professor of Zoology.
Elijah Lynn Grover, B. S., Associate Professor of Agricultural Education.
Frederick William Fabian, B. S., Associate Professor of Bacteriology and Hygiene.
Arnold George Scheele, A. M., Associate Professor of Drawing and Design.
John Eric Burnett, B. S., M. Agr., Associate Professor of Dairy Husbandry.
Anna Eliza Bayha, B. A., Associate Professor of Home Economics.
Chester Lawrence Allen, M. A., C. E., Associate Professor of Civil Engineering.
Leroy Stewart Foltz, M. E., Associate Professor of Electrical Engineering.
Roy Edgar Marshall, M. S., Associate Professor of Pomology.
Henrik Joakim Stafseth, B. S., D. V. M., Associate Professor of Bacteriology.

Guy Greene Speeker, A. M., Associate Professor of Mathematics.
Stanley Edwin Crowe, A. B., Associate Professor of Mathematics.
Frank Azor Spragg, M. S., Associate Professor of Farm Crops.
John Truman Horner, M. A., Associate Professor of Economics.
Oren Leone Snow, B. S., Associate Professor of Physics.
Lola Grace Yerkes, B. S., Associate Professor of Home Economics.
Henry Townsend Darlington, M. S., Associate Professor of Botany.
Ernest Clifford Foreman, B. S. A., Associate Professor of Poultry Husbandry.
Rufus Percival Hibbard, Ph. D., Associate Professor of Botany.
[3]Ethel Gladys Webb, B. S., Associate Professor of Home Economics.
Paul Stanley Lucas, B. S., Associate Professor of Dairy Manufactures.
John W. Scott, M. A., Associate Professor of Economics.
Frederick Charles Bradford, M. S., Associate Professor of Horticulture.

ASSISTANT PROFESSORS.

Ren George Saxton, C. E., Assistant Professor of Civil Engineering.
Thomas Gunson, Assistant Professor of Horticulture.
Claude Marshal Cade, C. E., Assistant Professor of Civil Engineering.
Walter Edward Reuling, B. S. in M. E., Assistant Professor of Mechanical Engineering.
Dwight Tarbell Ewing, Ph. D., Assistant Professor of Chemistry.
Edward Fred Woodcock, Ph. D., Assistant Professor of Botany.
John White Steward, B. M. E., Assistant Professor of Drawing and Design.
Howard Eckler Johnson, D. V. M., Assistant Professor of Comparative Anatomy.
Robert Earl Loree, B. S., Assistant Professor of Horticulture.
Clive Raymond Megee, B. S., A. M., Assistant Professor of Farm Crops.
Russell Alger Runnells, D. V. M., Assistant Professor of Animal Pathology.
Norma L. Gilchrist Roseboom, A. B., Assistant Professor of English.
Mary Hendrick, B. A., Assistant Professor of History.
Eugenia Inez McDaniel, A. B., Assistant Professor of Entomology.
Warren Wayland Hitchcock, B. S., Assistant Professor of Civil Engineering.
Louise Isabel Clemens, B. S., Assistant Professor of Home Economics.
Burt Kennedy Philp, C. E., Assistant Professor of Civil Engineering.
Henry Lantz Publow, B. S., Chem. E., Assistant Professor of Chemistry.
Godfrey Leonard Alvin Ruehle, M. S., Assistant Professor of Bacteriology.
Leo Cecil Hughes, A. M., Assistant Professor of French.
Perry Salem Brundage, B. S., Assistant Professor of Chemistry.
Ray Bennett Weaver, A. M., Assistant Professor of English.
Omer Marie Lebel, Ph. B., Assistant Professor of French.
Osee Hughes, A. B., Assistant Professor of Home Economics.
Edwin Morrison, M. S., Assistant Professor of Physics.
Wallace Larkin Chandler, Ph. D., Professor of Entomology.
Oliver A. Taylor, D. V. M., Assistant Professor of Anatomy.
Edmund Chester Sauve, B. S., Assistant Professor of Farm Mechanics.
Vernon Guy Grove, M. A., Assistant Professor of Mathematics.

Edward Karns Sales, D. V. M., Assistant Professor of Surgery and Medicine.

Captain Joseph Jesse Teter, Assistant Professor of Military Science.

Caroline Louise Holt, Assistant Professor of Drawing and Design.

William Edward Judson Edwards, B. S. A., Assistant Professor of Animal Husbandry.

Earle Henry Stewart, B. S., in M. E.; Assistant Professor of Drawing and Design.

Lawrence Clifford Wheeting, M. S., Assistant Professor of Soils.

Walter LeRoy Mallman, B. S., Assistant Professor of Bacteriology.

George Clarence Wright, B. S. in M. E., Assistant Professor of Mechanical Engineering.

Floyd Earl Fogle, B. S., Assistant Professor of Farm Mechanics.

Claude Lamar Brattin, B. M. E., Assistant Professor of Drawing and Design.

Newton Lyman Partridge, Ph. D., Assistant Professor of Horticulture.

[4]Bertha Emogene Thompson, M. A., Assistant Professor of Botany.

Charles Dodson Ball, B. S., Assistant Professor of Chemistry.

Albert Henry Nelson, A. M., Assistant Professor of English.

Josephine Rena Fogle, B. S., Assistant Professor of Home Economics Education.

Captain William Curtis Chase, A. B., Assistant Professor of Military Science.

Charles Evans Cormany, M. S., in Agr., Assistant Professor of Farm Crops.

Grosvenor W. Putnam, M. S., Assistant Professor of Farm Crops.

Emma Pauline Garrison, B. S., Assistant Professor of Home Economics and Home Economics Education.

Captain Gaillard Pinckney, Assistant Professor of Military Science.

Paul M. Harmer, Ph. D., Assistant Professor of Soils.

George William Hobbs, B. S., Assistant Professor of Mechanical Engineering.

Branson A. Walpole, B. S., Assistant Professor of Agricultural Education.

Lyman L. Frimodig, B. S., Assistant Director of Physical Education.

Captain Harrison Bruce Beavers, Assistant Professor of Military Science.

Robert Mifflin Snyder, Ph. D., Assistant Professor of Bacteriology.

Robert L. Tweed, M. S., Assistant Professor of Bacteriology.

Captain Webster Hamlin Warren, A. B., Assistant Professor of Military Science.

Captain Lawrence Byron Wyant, Assistant Professor of Military Science.

Marie Dye, Ph. D., Assistant Professor of Home Economics.

Royal Stewart Steiner, A. M., Assistant Professor of Economics.

John Conley DeCamp, B. S., Assistant Professor of Forestry.

[5]Walter Ruskin Stark, A. B., Assistant Professor of Economics.

INSTRUCTORS.

Dewey Alsdorf Seeley, M. S., Instructor in Meteorology.

Louis Brawley Mayne, A. B., Instructor in English.

Joseph William Stack, M. S., Instructor in Zoology.
Stanard Gustaf Bergquist, A. B., Instructor in Geology.
Howard David Lightbody, M. S., Instructor in Chemistry.
[4]Harry Curtis Young, M. S., Instructor in Botany.
Andrew Peter Krentel, Instructor in Mechanical Engineering.
George J. Posthumus, Instructor in Mechanical Engineering.
Helen Deborah Grimes, Instructor in Physical Education.
Edward Franklin Eldridge, B. S., Instructor in Chemistry.
Justus Rising, M. E., Instructor in Drawing and Design.
Jacob Austin Eicher, Instructor in Mechanical Engineering.
Eldon Eugene Down, B. S., Instructor in Farm Crops.
Oscar William Fairbanks, B. S., Instructor in Drawing and Design.
David Thomas Millard, Instructor in Mechanical Engineering.
Walter Leslie Watt, Instructor in Mechanical Engineering.
Russell Hiram Kelty, B. S., Instructor in Apiculture.
Raymond Leroy Baxter, B. S., Instructor in Chemistry.
Fletcher Amos Gould, B. S., Instructor in Civil Engineering.
Edward Everett Kinney, B. S., Instructor in Electrical Engineering.
Harold Malcolm Krebs, B. S., Instructor in Chemistry.
Wilfred Carl Lewis, A. M., Instructor in Chemistry.
Clifford Neal Rix, Instructor in Mechanical Engineering.
James Earl Robertson, B. S., Instructor in Mathematics.
Wilbur Herman Thies, B. S., Instructor in Physics.
John George Heppinstall, Instructor in Physical Education.
James Hugh Dever, Instructor in Physical Education.
Louis Gustave Gentner, M. S., Instructor in Entomology.
J. Robert Duncan, Instructor in Farm Crops.
Bert Sangster, Instructor in Mechanical Engineering.
[6]George Fearson Davis, B. S., Instructor in Poultry Husbandry.
[7]Irma Hannah Gross, B. S., Instructor in Home Economics.
Ralph Elmer Hammond, Instructor in Farm Mechanics.
Ralph Craig Huffer, A. M., Instructor in Mathematics.
Patricia MacDonald, Instructor in Voice.
James Walker Milne, A. B., Instructor in Public Speaking.
Edith Butler, Instructor in Drawing.
Joseph Foley, 1st Sergt. U. S. A., Instructor in Military Science.
Sylvia Irene Borgman, B. S., Instructor in Home Economics.
Harriet Young Colvin, Instructor in Home Economics; in charge of Flower Pot Tea Room.
Ruth Mary Cowan, M. S., Instructor in Home Economics.
Florence Adele Keepman, B. S., Instructor in Home Economics.
Rachel Harriet Talbot, M. A., Instructor in Home Economics.
James Henry Atchison, Sergt. U. S. A., Instructor in Military Science.
Ruth Harriet Wilson, Ph. B., Instructor in Home Economics.
[3]Josephine Hoffarth, Ph. B., Instructor in Home Economics.
George Arnold Getman, Instructor in Farm Mechanics; Field Foreman in Farm Crops.
Herman Joseph Gallagher, B. S., Instructor in Farm Mechanics.
Fred Thomas Riddell, B. S., Instructor in Farm Management.
Lewis W. Green, Sergt. U. S. A., Instructor in Military Science.
John Herbert Harman, B. S., Instructor in Entomology.
Ray Nelson Haskell, B. S., Instructor in Mathematics.

James Mayberry Earl, A. B., Instructor in Mathematics.
Jeremiah Meskill, Sergt. U. S. A., Instructor in Military Science.
Orville Bryan Price, B. S., A. M., Instructor in Soils.
Leslie Alva Kenoyer, Ph. D., Instructor in Botany.
William Earl Workman, Sergt. U. S. A., Instructor in Military Science.
Charles Patrick Riley, Sergt. U. S. A., Instructor in Military Science.
Arthur McKercher, V. S., Instructor in Ambulatory Clinic.
George Wesley Whiting, A. M., Instructor in English.
Chester Ferdinand Kuhn, A. B., Instructor in English.
Oscar Cargill, B. S., Instructor in English.
Clarence Paul Hotson, M. A., Instructor in English.
Ernest Paul Lewis, M. S., Instructor in Horticulture.
Fred Mitchell Walker, Ph. B., Instructor in Physical Education.
Leon Duane Burhans, Instructor in Physical Education.
Richard H. Rauch, B. S., Instructor in Physical Education.
Blanche Rosamond Vaughan, Instructor in Physical Education.
Grace Maria Keefe, B. S., Instructor in Physical Education.
Paul Anthony Herbert, M. F., Instructor in Forestry.
Marion Louise Grettenberger, B. S., Instructor in Chemistry.
Gertrude Lloyd Clark, Instructor in Piano.
Delia H. Bemis, Instructor in Violin.
[5]Niels Peterson, M. A., Instructor in Zoology.

S. Elisabeth Morrison, A. B., Assistant in Physics.
[9]Earl Lee Hemenway, A. B., Assistant in Economics.
Hubert McClure Brown, B. S., Assistant in Farm Crops.
[3]Fred Harvey Knox, B. S., Assistant in Farm Crops.
Dorothy Martha Yakeley, B. S., Assistant in Bacteriology.
Ralph Cleon Thomas, B. S., Assistant in Bacteriology.
Daniel Edward Hasley, B. S., Assistant in Bacteriology.
Dayton Ray Yoder, A. B., Assistant in Soils.
William James Sweetman, B. S., Assistant in Dairy Husbandry.
Russell Rawson Palmer, B. S., Assistant in Dairy Husbandry.
Roy James Werdon, B. S., Assistant in Dairy Husbandry.
Reid Leicester Rayner, B. S., Assistant in Electrical Engineering.
Clare F. Jolley, B. S., Assistant in Entomology.
William Ralph Wilson, B. S., Assistant in Chemistry.
Gladys Kidder Wardwell, B. S., Assistant in Chemistry.
Henry Richard Adams, B. S., Assistant in Soils.
[10]Carl Curt Dethloff, B. S., Assistant in Soils.
Dewey Stewart, B. S., Assistant in Botany.
Delbert Swartz, B. S., Assistant in Botany.
Miriam Clark Carpenter, B. S., Assistant in Botany.
John Rufus Cole, B. S., Assistant in Botany.
Paul Robert Miller, B. S., Assistant in Farm Crops.
William Horace Hosterman, B. S., Assistant in Farm Crops.
Brittain Bragunier Robinson, B. S., Assistant in Farm Crops.
[8]Ruth Sullivan Rowland, B. S., Assistant in Education.

Carl Guy Card, Director of Guidance School; Instructor in Vocational School.
Myrtle Maguire, Instructor in Vocational School.
George Albert Trollope, Instructor in Vocational School.
J. Conrad Kremer, Instructor in Vocational School.
William A. Luther Williard, Instructor in Vocational School.

James Blood Hasselman, A. B., Supervisor of Publications.
Edwyn Alfred Bowd, College Architect.
Lory Francis Newell, Operating Engineer.
Alexander Borland, M. D., Director of Health Service.
Ralph Stoll Hudson, B. S., Superintendent of Farm.
Elmer Bruce Hint, B. S., Superintendent of Official Testing.
Ralph M. Harford, College Photographer.
[6]Frances Murdock, In Charge of Maude Gilchrist House.
Nancy L. Eastman, In Charge of College Residence.
Pearl Weamer, In charge of Katherine Friday House.
Helen Dow, In charge of Waterbury House.
Vinnie Baker, In Charge of Abbot Hall.
Ida R. Reasoner, Matron, Woman's Building.
Edward Chauncey Crawford, Laboratory Engineer, R. E. Olds Hall of Engineering.
Marguerite Barker, R. N., Nurse.
Earl A. Harlow, Storekeeper.
William Wise, Foreman of Poultry Plant.
Jesse J. Hendryx, Foreman Forest Nursery.
[13]Florence K. Middaugh, Ph. B., Assistant to the President.
[14]Earl L. Hemmenway, A. B., Assistant in Economics.

SPECIAL SHORT COURSE INSTRUCTORS.

Elton Brainard Hill, B. S., M. Agr., Director.
Ashley Moses Berridge, B. S., M. Agr., Assistant Director.
Bert A. Powell, Farm Mechanics.
Robert Mackie, Animal Husbandry.
Lawrence J. Kurtz, B. S., Farm Crops.
Dean Kelley, Business Law.
Herman C. Jordan, Cheesemaking.
Howard Mitchell Wells, B. S., Horticulture.

---

[2] Appointed Acting President June 1, 1923.
[3] Appointed January 1, 1923.
[4] Absent on leave.
[5] Appointed April 1.
[6] Resigned March 1.
[7] Absent on leave, spring term.
[8] Appointed February 1.
[9] Resigned May 1, 1923.
[10] Resigned April 1.
[11] Resigned May 10.
[12] Resigned June 1, 1923.
[13] Resigned July 1, 1923.
[14] Resigned May 1, 1923.

EXPERIMENT STATION

Advisory and Assistant Staff.

ANDREW J. PATTEN, B. S., Chemist.
GEORGE J. BOUYOUCOS, Ph. D., Research Professor of Soils.
CHARLES S. ROBINSON, Ph. D., Research Associate in Chemistry.
ORRIN B. WINTER, B. A., Research Associate in Chemistry.
LESLIE H. COOLEDGE, M. A., Research Associate in Bacteriology.
I. FOREST HUDDLESON, M. S., Research Associate in Bacteriology.
GEORGE M. GRANTHAM B. S. (one-half time, balance Extension), Research Associate in Soils.
CHARLES H. SPURWAY, B. S. in Agr., Research Associate in Soils.
RAY NELSON, B. S., Research Associate in Plant Pathology.
WALTER C. DUTTON, B. S., Research Associate in Horticulture.
ROBERT M. SNYDER, Ph. D., Research Assistant in Bacteriology.
JOHN E. KOTILA, M. S., Research Assistant in Plant Pathology.
CARLYLE W. BENNETT, M. S., Research Assistant in Plant Pathology.
H. R. PETTIGROVE, B. S., Research Assistant in Farm Crops. (Upper Peninsula.
JETHRO O. VEATCH, A. B., Research Assistant in Soils.
HOWARD M. WELLS, B. S., Research Assistant in Horticulture.
JAMES TYSON, Research Assisant in Soils.
ELROY J. MILLER, M. S., Assistant in Chemistry.
DUANE RAINEY, B. S. (one-third time only, balance Extension) Assistant in Farm Crops.
H. DONALD HOOTMAN, B. S., Superintendent of Graham Horticultural Experiment Station.
D. L. MCMILLAN, Superintendent of Upper Peninsula Experiment Station.
MYRA V. BOGUE, Bulletin Clerk.
A. W. LOWELL, B. S., Assistant in Chemistry.
C. F. HUFFMAN, M. S., Assistant in Dairy Husbandry.
FRANK TRULL, B. S., Assistant in Soils.
A. G. WEIDEMANN, B. S., Assistant in Soils.

AGRICULTURAL EXPERIMENT STATION

OF THE

MICHIGAN AGRICULTURAL COLLEGE

(Under the control of the State Board of Agriculture.)

STATION COUNCIL.

Robert Sidey Shaw, D. Agr.	Director
Rufus Hiram Pettit, B. S. A.	Entomologist
Andrew Jarvis Patten, B. S.	Chemist
Ernest Atheran Bessey, Ph. D.	Botanist
Ward Giltner, D. V. M., M. S.	Bacteriologist
Alfred Knight Chittenden, M. F.	Forester
Merris Mickey McCool, Ph. D.	Soil Physicist
Victor Ray Gardner, M. S.	Horticulturist
George Arthur Brown, B. S.	Animal Husbandman
Harry Hayes Musselman, B. S.	Farm Mechanics
Elam Tandy Hallman, D. V. M.	Animal Pathologist
Joseph Frank Cox, B. S. A.	Farm Crops
Ollie Ezekiel Reed, M. S.	Dairy Husbandman
Ernest Clifford Foreman, B. S. A.	Poultry Husbandman
Elton Brainard Hill, M. Agr.	Assistant to Director
Herman H. Halladay	Secretary

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS

ADMINISTRATIVE OFFICE.

Robert James Baldwin, B. S.	Director of Extension Work
Hale Tennant, B. S.	Assistant Extension Director in charge of County Agents and Markets
Karl H. McDonel, B. S.	Assistant to Director

EXTENSION SPECIALISTS.

James Blood Hasselman, A. B.	Publicity
H. E. Dennison, B. S.	Dairying
Verne A. Freeman, B. S.	Animal Husbandry
G. W. Putnam, B. S.	Farm Crops
Howard C. Rather, B. S.	Farm Crops
Duane F. Rainey, B. S.	Farm Crops
Henry C. Moore, B. S.	Potatoes and Vegetables
James Wade Weston, B. S.	Potatoes and Vegetables
John Harman, B. S.	Insect Control
Edwin Ewell	Apiculture
Orsel Edwin Robey, B. S.	Drainage & Household Engineering
T. A. Farrand	Horticulture
L. F. Livingston, B. S.	Land Clearing
A. J. McAdams, B. S.	Land Clearing
George Amundson	Land Clearing
A. C. Baltzer, B. S.	Dairying
Stanley J. Brownell, B. S.	Dairying
James G. Hays, B. S.	Dairying
Robert Addy	Dairying
James G. Wells, Jr., B. S. A.	Dairying
Karl H. Miller, B. S.	Dairying
Paul M. Harmer, Ph. D.	Soils
George Manners Grantham, B. S.	Soils
C. M. Ferguson, B. S.	Poultry
Raymond David Ure, B. S.	Poultry
Gifford Patch, Jr., B. S.	Assistant in Marketing
Willard C. Cribbs	Assistant in Marketing
Louise H. Campbell, B. S.	State Leader, Home Economics
Mariel Hopkins, B. S.	Nutrition
Eunice Ryan, M. A.	Clothing & Textiles
Marian Harriet Rogers, B. S.	Home Management
H. A. Cardinell, B. S.	Horticulture
George E. Starr	Horticulture
Larry D. Kurtz, B. S.	Farm Crops
James B. Haskins	Rural Press
Eben Mumford, Ph. D.	Extension Lecturer

COUNTY AGRICULTURAL AGENTS.

Hale Tennant, B. S.	In Charge of County Agents
Roswell G. Carr, B. S.	Assistant State Leader of County Agents
Clinton V. Ballard, B. S.	Assistant State Leader of County Agents
E. G. Amos, B. S.	Assistant State Leader of County Agents.
C. P. Johnson, B. S.	Alpena
O. I. Gregg, B. S.	Allegan
Colond M. McCrary, B. S.	Alpena

L. L. Drake, B. S.	Antrim
Lewis J. Carter, B. S.	Arenac
Frank W. Bennett	Barry
James L. Kraker, B. S.	Benzie
Frank L. Simanton, B. A., M. S.	Berrien
Claude Lawrence Nash, B. S.	Branch
Bishop B. Adams, D. V.	Calhoun
E. L. Kunze, B. S.	Cass
Don B. Jewell, B. S.	Cheboygan
Howard V. Kittle, B. S.	Clinton
R. D. Bailey, B. S.	Crawford
Joseph E. Turner, B. S.	Delta
Arthur J. Lonsdorf, B. S.	Dickinson
Ralph W. Tenny, B. S.	Eaton
Dwight C. Cavanagh, B. S.	Emmet
Sidney Samuel Smith, B. S.	Genesee
Carl E. Gunderson, B. S.	Gogebic
Charles E. Atwater, B. S.	Grand Traverse
Cecil Perth Pressley, B. S.	Gratiot
Roy W. Weinberg, B. S.	Hillsdale
Leo M. Geismar	Houghton
E. E. Twing	Huron
Ralph L. Helm, B. S.	Ionia
Earl R. Roberts, B. S.	Iron
Roy E. Decker, B. S.	Jackson
R. Leslie Olds, B. S.	Kalamazoo
Errol S. Bird, B. S.	Kalkaska
Keats K. Vining, B. S.	Kent
A. J. Patch, B. S.	Lapeer
C. L. Coffeen, B. S.	Lenawee
C. L. Bolander	Livingston
Roy Harry Cameron, B. S.	Luce
William Murphy, B. S.	Macomb
Harold M. Vaughn, B. S.	Manistee
Lee Roy Walker, B. S.	Marquette
Kris P. Bemis	Mason
Murray F. Jackson	Mecosta
Karl Knaus, B. S.	Menominee
Ira B. McMurtry, B. S.	Midland
Clare L. Burton, B. S.	Monroe
B. Eldon Shaffer	Montcalm
Carl H. Knopf, B. S.	Muskegon
Clair Taylor	Newaygo
Charles B. Cook, B. S.	Oakland
I. T. Pickford, B. S.	Oceana
William Edward McCarthy, B. S.	Ogemaw
W. Noble Clark, B. S.	Ontonagon
Arthur C. Lytle, B. S.	Otsego
Clinton Pomeroy Milham, B. S.	Ottawa
Ivan J. Sours, B. S	Presque Isle
A. G. Bovay, B. S.	Saginaw
John D. Martin, B. S.	Sanilac

Carl May Kidman, B. S.	St. Clair
L. R. Binding, B. S.	St. Joseph
Tracey R. Shane	Schoolcraft
J. Vernon Sheap	Shiawassee
John W. Sims, B. S.	Tuscola
Wesley Clare Eckard, B. S.	Van Buren
Harold S. Osler, B. S.	Washtenaw
Ralph J. Carr, B. S.	Wayne
William F. Johnston, B. S.	Wexford

HOME DEMONSTRATION AGENTS.

Louise H. Campbell, B. S.	State Home Demonstration Agent Leader
Edna Viola Smith, B. S.	Assistant State Leader
Adele Koch, M. A.	Assistant State Leader
Ida M. Sichler, B. S.	Assistant State Leader
Muriel Dundas, B. S.	Allegan
Ruth Wheatley, B. S.	Gogebic
Sylva Wixson, B. S.	Marquette
Blanche Clark	Kalamazoo
Eva Carrett	Oakland
Eva Schurr, B. S.	Ottawa
Bernice Woodworth, B. S.	Wayne

BOYS' AND GIRLS' CLUB WORK.

Ray A. Turner, B. S.	State Club Leader
Barbara VanHeulen, B. S.	Assistant State Club Leader
Elda Iantha Robb, B. S.	Assistant State Club Leader
Ruth M. Cresswell, B. S.	Assistant State Club Leader
Arne Gerald Kettunen, B. S.	Assistant State Club Leader
Nevels Pearson, B. S. A.	Assistant State Club Leader
Viva L. Osborn	Branch
W. C. Boman, B. S.	Calhoun
Ann Rosale Banks	Cheboygan
Mary V. Hall	Iron
Freeman M. Karn, B. S.	Lapeer & Macomb
George S. Hedrick, B. S.	Lenawee
George H. Kimball, Jr.	Oakland
A. L. Watt, B. S. A.	Washtenaw
J. W. Wagner	Wayne

ACCOUNT OF THE

MICHIGAN AGRICULTURAL COLLEGE

FOR THE YEAR ENDING JUNE 30, 1923

SECRETARY'S FINANCIAL REPORT.

July 1, 1922.	Cash on hand			$5,375 94	
July 1, 1922.	Cash on deposit overdrawn				$58,592 92
June 30. 1923.	To special appropriation receipts			547,627 63	
	From State Treasurer		$338,842 59		
	Experiment station	$180,000 00			
	Extension	70,000 00			
	Extension, Sec. 1, Act 115, 1921	70,000 00			
	Vocational teacher's training	18,842 59			
	From United States Treasurer		189,913 95		
	Experiment Station	30,000 00			
	Extension	159,913 95			
	Institution and interdepartment transfers.		18,871 09		
	By special disbursements				570,135 09
	Special appropriation	22,326 14			
	Experiment Station	246,038 21			
	Extension	301,770 74			
June 30, 1923	To current account receipts			1,311,742 57	
	From State Treasurer, land grant int		70,618 98		
	From State Treasurer, one-fifth mill tax		750,000 00		
	(a) 1,000,000.00				
	(b) 180,000 00				
	(c) 70,000 00				
	From U. S. Treas., Morrill Fund		50,000 00		
	Institution and interdepartment transfers.		44,123 59		
	By disbursements, general account				1,311,337 96
June 30, 1923.	By cash on hand				3,455 53
	By cash on deposit overdrawn			78,775 36	
				$1,943,521 50	$1,943,521 50

(a) Mill tax.
(b) Appropriated for Experiment Station.
(c) Appropriated for Extension.

TABLE NO. 1.—*Tabular Exhibit of Secretary's Reports.*

	Balance Sheet July 1, 1922		Transactions July, 1, 1922 to June 30, 1923		Balance Sheet June 30, 1923	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Cash	$5,375 94		$1,920 41		$3,455 53	
(a) College Treasurer		$58,592 92	20,182 44			$78,775 36
Special Appropriations	7,115 18		24,307 71	$22,056 89	4,864 36	
Current Accounts		28,682 70	1,207,898 92	1,215,379 16		21,202 46
Experiment Station	103,376 23		221,505 74	240,849 86	122,720 35	
Extension		28,591 73	300,931 53	298,460 84		31,062 42
Interdepartment transfer			104,726 30	104,726 30		
Total	$115,867 35	$115,867 35	$1,881,473 05	$1,881,473 05	$131,040 24	$131,040 24

(a) Treasurer's statement is greater July 1, 1922, by $70,549.95, and June 30, 1923, by $115,468.74. Warrants and deposits outstanding.

TREASURER'S ACCOUNT

	Dr.	Cr.
Balance on hand July 1, 1922	$11,957 03	
Receipts from State Treasurer and Secretary of College	1,773,202 38	
Interest on deposits during the year	896 28	
Warrants paid July 1, 1922, to June 30, 1923		$1,749,362 31
Balance on hand June 30, 1923		36,693 38
Total	$1,786,055 69	$1,786,055 69

TABLE NO. 3.—*Statement of special appropriation accounts for the fiscal year ending June 30, 1923.*

	Balance of accounts July 1, 1922		Receipts		Total available	Total expended	Balance of accounts June 30, 1923	
	Dr.	Cr.	From State Treasurer	From institution and other sources			Dr.	Cr.
Experiment Station	$107,967 26		(a) $210,000 00	$12,378 39	$114,411 13	$246,038 21	$131,627 08	
Extension		$25,883 89	(b) 299,913 95	1,027 58	326,825 42	301,770 74		$25,054 68
Geo. L. Allen Scholarship		186 38		50 00	236 38			236 38
Lawson Memorial Prize				12 50	12 50	25 00	12 50	
Marilla Griswold Scholarship		66 17		55 00	121 17			121 17
Sayer Fund		24 70		12 50	37 20	25 00		12 20
M. A. C. Scholarship		322 11		140 00	462 11			462 11
Sanford Memorial Fund				4,522 71	4,522 71			4,522 71
Vocational Teacher's Training	7,247 69		18,842 59		11,594 90	22,081 81	10,486 91	
Home Economics Building	408 58			602 91	602 91	194 33		
Library Building	69 50			69 50	69 50			
Totals	$115,693 03	$26,483 25	$528,756 54	$18,871 09	$458,895 93	$570,135 09	$142,126 49	$30,409 15

(a) $30,000 00 United States Treasurer.
(b) $159,913 95 United States Treasurer.

TABLE NO. 4.—*William Smith Sayer Scholarship Fund.*

Fund	Year ending June 30	Income	Income expended to	Amount	Balance including principal
$500.00 received of F. B. Sayer, administrator of the estate of William Smith Sayer, to establish Scholarship in Bacteriology..........................	1910	$32 25	A McVittie..................	$19 75	$512 50
	1911	37 50	....	....	550 00
	1912	12 50	D. K. Fisher................. H. D. Wright................	25 00 25 00	512 50
	1913	25 00	D. Francisco.................	25 00	512 50
	1914	24 85	R. W. Waffle.................	25 00	512 35
	1915	24 85	J. D. Baker..................	25 00	512 20
	1916	25 00	J. M. Maze...................	25 00	512 20
	1917	25 00	Elsa Scheuren................	25 00	512 20
	1918	25 00	....	....	537 20
	1919	25 00	Elwyn Younker............... Ethel Hoppan................	25 00 25 00	512 20
	1920	25 00	Esther Severance............	25 00	512 20
	1921	37 50	Thelma Porter...............	25 00	524 70
	1922	25 00	Herman E. Segelin...........	25 00	524 70
	1923	12 50	Dorothy Jermin..............	25 00	512 20
Total		$356 95	....	$344 75	......

Table 5.—*Geo. E. Lawson Memorial Prize.*

Fund	Year ending June 30	Income	Income expended to	Amount	Balance including principal
$500.00 received of John W. Beaumont, in memory of Geo. E. Lawson to offer annual cash prize for the best essay in English produced by male student....	1917	$25 00	I. B. McMurtry..............	$25 00	$500 00
	1918	12 50	H. C. Diehl	25 00	487 50
	1919	25 00	Stanley Powell..............	25 00	487 50
	1920	25 00	Fred F. Henshaw.............	25 00	487 50
	1921	25 00	Herman E. Segelin...........	25 00	487 50
	1922	37 50	C. R. Clausen...............	25 00	500 00
	1923	12 50	Benjamin Halsted............	25 00	487 50
Total		$162 50		$175 00	

TABLE NO. 6.—*Geo. L. Allen Scholarship*

Fund	Year ending June 30	Income	Income expended to	Amount	Balance including principal
$1,000.00 received of Amanda A. Ransom to be used in assisting the poor and deserving young men in obtaining their education..........................	1919	....	....	....	$1,036 38
	1920	50 00	....	....	1,086 38
	1921	75 00	....	....	1,161 38
	1922	25 00	....	....	1,186 38
	1923	50 00	....	....	1,236 38
Total		$200 00		..	..

TABLE NO. 7.—*Marilla Griswold Scholarship.*

Fund	Year ending June 30	Income	Income expended to	Amount	Balance including principal
$2,000.00 received of Orion S. Cross, Executor of the estate of Marilla Griswold the income of the same to be used under the direction of the State Board of Agriculture to help needy students. Preference to be given to those from Allegan County	1920	$110 00		13 83	$2,096 17
	1921	110 00			2,206 17
	1922	110 00	Emma Culver	$250 00	2,066 17
	1923	55 00			2,121 17
Total		$385 00		$263 83	

TABLE NO. 8.—*M. A. C. Scholarship.*

Fund	Year ending June 30	Income	Income expended to	Amount	Balance including principal
$4,000.00 derived from daily balances of the M. A. C. trust funds and exchange charges collected at office. Income to be given that man and that woman respectively who shall have shown best scholastic records	1922	$140 00			$4,140 00
	1923	140 00			4,280 00
Total		$280 00			

TABLE NO. 9.—*Current Account July 1, 1922, to June 30, 1923*

	Dr. To Disbursements	Cr. By Receipts
U. S. Treasurer, 33rd annual payment under act of Congress of August, 1890		$50,000 00
State Treasurer, one-fifth mill fund		750,000 00
State Treasurer, interest on proceeds of sale of U. S. land grant		70,618 98
Anatomy	$12,078 24	1 93
Animal Husbandry	32,711 85	13,180 37
Applied Science	6,969 60	
Bacteriology	20,807 12	7,335 84
Botany	26,213 40	84 13
Chemistry	58,741 43	2,092 25
Civil Engineering	20,875 77	
Dairy Husbandry	65,983 35	34,284 45
Drawing	31,560 34	878 43
Economics	22,121 96	1 50
Electrical Engineering	15,561 52	1 75
English	30,853 32	
Entomology	13,768 15	165 65
Farm Crops	18,488 37	
Farm and Horses	50,139 33	338 56
Farm Mechanics	11,510 39	282 63
Farm Management	3,962 03	
Fees		125,344 75
Forestry	16,525 10	5,248 23
History	8,185 28	
Home Economics	60,594 67	2,637 96
Horticulture	21,222 37	1,588 44
Landscape and Design	4,260 23	
Library	13,600 24	59 72
Mathematics	26,098 66	
Mechanical Engineering	35,394 16	519 89
Military	3,629 09	17 12
Music	8,366 96	
Meteorology	600 00	
Pathology	4,866 37	
Physics	23,815 92	1,796 43
Physical Training	28,507 21	5,653 64
Poultry	21,039 31	8,259 55
Soils	13,850 11	163 82
Special Courses	12,319 71	101 50
Surgery and Medicine	11,446 81	1,407 57
Zoology	16,295 90	17 75
Alumni Recorder	4,607 36	2 95
Dean of Agriculture	4,081 18	213 82
Dean of Engineering	7,964 55	25 00
Dean of Summer School	17,039 34	1 05
Office of President	22,315 18	3,273 46
Office of Secretary	29,287 41	613 46
Registrar	9,606 55	
Advertising	3,202 59	.50
Convocations	708 78	.70
Commencement	792 17	9 00
Diplomas	866 68	1,373 00
Expense Board Members	724 24	
Federal Students	19,630 42	44,128 06
Fairs	2,894 84	1,469 63
General Lectures	302 39	
Health Service	14,426 07	232 04
Miscellaneous	2,194 84	1,164 08
Store	71,259 69	68,046 32
Cleaning	24,051 67	802 76
Electric Lights	12,986 13	2,112 53
Freight and Cartage	10,155 75	421 62
General Expenses	18,171 53	.70
Heating	106,212 39	1,183 24
Maintenance of Grounds	7,414 97	274 50
Maintenance and Repair of Buildings and Land Improvement	85,523 72	(a) 42,604 95

TABLE NO. 9.—*Continued.*

	Dr. To Disbursements	Cr. By Receipts
Telephones	$2,746 98	$139 42
Fire Equipment	501 63	
Purchase and Rental of Lands	1,750 00	4,394 00
New Buildings and Additions	56,917 52	994 12
Loan Fund		25,000 00
Total	$1,311,300 85	$1,311,742 57
Balance beginning fiscal year July 1, 1922		27,606 33
Balance on hand June 30, 1923	29,087 31	
Total	$1,340,388 16	$1,339,348 90

(a) Includes room rent, $29,432.55, tuition fees, $4,463.00, matriculation, $3,087.50.

TABLE NO. 10.—*Distribution of Special Appropriations.*

	Dr. To disbursements	Cr. By receipts
Sayer Fund	$25 00	$12 50
G. E. Lawson Memorial Fund	25 00	12 50
G. L. Allen Scholarship		50 00
Marilla Griswold Scholarship		55 00
Vocational Teachers' Training	21,812 56	18,842 59
M. A. C. Scholarship Fund		140 00
Sanford Memorial Fund		4,522 71
Home Economics Building	194 33	602 91
New Library Building		69 50
Total	$22,056 89	$24,307 71
Balance (overdrawn) beginning fiscal year July 1, 1922	7,115 18	
Balance (overdrawn) on hand June 30, 1923		4,864 36
Total	$29,172 07	$29,172 07

TABLE NO. 11.—*Experiment Station Account for Fiscal Year Ending June 30, 1923.*

	Disbursements			Dr. Total disbursements each department	Cr. Receipts
	Adams	Hatch	State		
Overdraft July 1, 1922				$107,967 26	
United States Treasurer					$30,000 00
State Treasurer, one-fifth mill fund					180,000 00
Animal Husbandry			$2,741 04	2,741 04	.73
Bacteriology			7,706 81	7,706 81	298 55
Botany			4,083 88	4,083 88	132 70
Chemistry			2,099 12	2,099 12	31 85
Dairy Husbandry			4,010 27	4,010 27	62 50
Director's Office			10,737 33	10,737 33	873 95
Economic Fund Survey			4,276 18	4,276 18	
Entomology			641 12	641 12	29 50
Farm Crops			11,929 74	11,929 74	3,418 35
Forestry			698 50	698 50	311 00
Farm Management			2,865 82	2,865 82	111 86
Farm Mechanics			836 44	836 44	
Horticulture			4,916 91	4,916 91	23 84
Library			994 62	994 62	
Poultry			4 30	4 30	
Salaries	$15,000 00	$15,000 00	108,191 10	138,191 10	
Soils			13,021 37	13,021 37	20 06
Graham Hort. Station			5,149 27	5,149 27	852 24
South Haven Station			4,303 83	4,303 83	629 94
Upper Peninsula Station			26,830 56	26,830 56	5,581 32
Balance overdrawn June 30, 1923					131,627 08
Totals	$15,000 00	$15,000 00	$216,038 21	$354,005 47	$354,005 47

TABLE NO. 12.—*Extension Account for Fiscal Year Ending June 30, 1923.*

	Lever	Lever State	State	Dr. Total disbursements for each Project	Cr. Receipts
Balance July 1, 1922					$25,883 89
U. S. Treasurer Lever Fund					159,913 95
State Treasurer Act 250, 1921					70,000 00
State Treasurer, 1-5 mill Extension Fund State					70,000 00
Administration		$13,705 80	$2,261 48	$15,967 28	6.05
Boys' and Girls' Club	$27,302 49	1,059 95	9,704 99	38,067 43	115 30
Control Insect Pests	1,000 00	3,000 00	2,766 18	6,766 18	
County Agents	85,597 53	567 53	3,276 14	89,441 20	503 30
Dairy Husbandry	11,212 87	1,933 29	7,475 98	20,622 14	20 00
Farm Crops	9,615 00		4,804 69	14,419 69	68 77
Farm Management		330 40	259 19	589 59	127 50
Home Management	2,550 00	323 80	572 57	3,446 37	48 36
Horticulture	1,973 35	3,225 00	3,889 56	9,087 91	
Household Engineering		3,550 50	1,464 76	5,015 26	20 00
Markets		14,412 50	4,965 54	19,378 04	
Potatoes and Vegetables		6,125 00	3,908 61	10,033 61	
Poultry		5,156 50	2,648 20	7,804 70	
Publications			5,250 05	5,250 05	5 85
Soils		2,675 00	2,012 84	4,687 84	
Home Demonstration Agents	14,382 31	730 05	2,421 74	17,534 10	102 45
Clothing and Textiles	2,380 40	292 96	848 71	3,522 07	
Food and Nutrition	3,000 00	240 30	1,193 22	4,433 52	
Land Clearing		9,573 11	4,936 62	14,509 73	10 00
Lectures			6,170 01	6,170 01	
Dairy Manufacturing			750 00	750 00	
Animal Husbandry	900 00	2,450 37	923 65	4,274 02	
Balance on hand June 30, 1923				25,054 68	
Total	$159,913 95	$69,352 06	$72,504 73	$326,825 42	$326,825 42

TABLE NO. 13.—*Positions and salaries as shown by pay-roll dated June 30, 1923.*

	Rate per year	Classification		
		Current	Experiment Station	Extension
Administration and Miscellaneous				
President's Office	$12,000 00	$12,000 00		
Acting President	5,500 00	5,500 00		
Assistant to President	3,000 00			
Clerk to President	1,300 00			
Clerk	1,200 00			
Clerk	1,200 00			
Secretary's Office:				
Secretary	5,500 00	5,000 00	$500 00	
Treasurer	4,000 00	3,500 00	500 00	
Bookkeeper	1,700 00	1,300 00	400 00	
Chief Clerk	1,600 00			
Clerk	1,500 00			
Clerk	1,200 00			
Clerk	1,400 00			
Purchasing Agent	3,200 00			
Registar's Office:				
Registrar	3,000 00			
Assistant	2,000 00			
Library:				
Librarian	2,800 00	2,400 00	400 00	
Reference Librarian	2,000 00			
Assistant Librarian	1,400 00			
Store:				
Storekeeper	1,800 00			
Assistant Storekeeper	1,200 00			
Clerk	1,200 00			
Advertising:				
Agent	3,200 00	1,000 00		
General:				
Engineer	2,800 00			
Night Watchman	1,300 00			
Draftsman	2,280 00			
Architect	3,500 00			
Superintendent of Buildings and Grounds	3,500 00			
Department of Health Service:				
Medical Officer	3,600 00			
Secretary	1,600 00			
Nurse	1,300 00			
Nurse	1,600 00			
Division of Home Economics:				
Professor	3,175 00			
Associate Professor	3,200 00			
Associate Professor	3,000 00			
Associate Professor	3,000 00			
Assistant Professor	3,000 00			
Assistant Professor	2,800 00			
Instructor	1,700 00			
Instructor	1,800 00			
Instructor	2,800 00			
Instructor	2,000 00			
Instructor	2,200 00			
Instructor	1,500 00			
Instructor	1,800 00			
Secretary	1,500 00			
Clerk	1,700 00			
Social Director	1,800 00			
Matron	1,500 00			
Matron	480 00			
Matron	480 00			
Matron	720 00			
Matron	480 00			

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Division of Applied Science:				
Professor	$6,000 00			
Clerk	960 00			
Department of Bacteriology:				
Professor	4,750 00	$3,150 00	$1,600 00	
Associate Professor	3,200 00	2,400 00	800 00	
Associate Professor	3,200 00	1,600 00	1,600 00	
Assistant Professor	3,400 00	1,200 00	2,200 00	
Assistant Professor	2,500 00	2,500 00		
Instructor	2,400 00	800 00	1,600 00	
Graduate Assistant	960 00	960 00		
Graduate Assistant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Clerk	1,500 00	700 00	800 00	
Research Associate	3,600 00		3,600 00	
Research Associate	2,800 00		2,800 00	
Research Associate	3,200 00		3,200 00	
Department of Botany:				
Professor	5,000 00	4,100 00	900 00	
Associate Professor	3,500 00	3,500 00		
Associate Professor	3,800 00	1,900 00	1,900 00	
Associate Professor	3,400 00	900 00	2,500 00	
Assistant Professor	3,000 00	3,000 00		
Assistant Professor	2,000 00	2,000 00		
Graduate Assiatant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Graduate Assiatant	800 00	800 00		
Research Assistant	2,400 00		2,400 00	
Research Assistant	1,300 00		1,300 00	
Stenographer	1,350 00	900 00	450 00	
Research Assistant in Plant Pathology	2,400 00		2,400 00	
Graduate Assistant	800 00		800 00	
Department of Chemistry:				
Professor	5,000 00			
Associate Professor	3,800 00			
Associate Professor	3,800 00			
Associate Professor	3,200 00			
Assistant Professor	3,000 00			
Assistant Professor	2,800 00			
Assistant Professor	2,600 00			
Assistant Professor	2,400 00			
Instructor	2,400 00			
Instructor	2,200 00			
Instructor	2,200 00			
Instructor	1,800 00			
Instructor	1,800 00			
Instructor	2,000 00			
Graduate Assistant	800 00			
Graduate Assistant	800 00			
Dispensing Clerk	1,800 00			
Stenographer	1,300 00			
Department of Physics:				
Professor	4,500 00			
Associate Professor	3,200 00			
Associate Professor	3,200 00			
Assistant Professor	2,700 00			
Instructor	2,300 00			
College Photographer	1,900 00			
Care-taker	1,300 00			
Laboratory Assistant	1,200 00			
Department of Zoology:				
Acting Professor	3,200 00			
Associate	3,200 00			
Instructor	2,500 00			
Instructor	2,400 00			
Instructor	2,400 00			

TABLE NO. 11.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Department of Entomology:				
Professor	$4,700 00	$3,100 00	$1,600 00	
Assistant Professor	3,400 00	1,400 00	2,000 00	
Assistant Professor	3,000 00	1,600 00	1,400 00	
Instructor	2,300 00	2,300 00		
Instructor	2,000 00	2,000 00		
Graduate Assistant	800 00	800 00		
Stenographer	1,200 00	1,200 00		
DIVISION OF ENGINEERING.				
Dean's Office:				
Dean	5,500 00	5,500 00		
Clerk	1,500 00	1,500 00		
Department of Drawing and Design:				
Professor	5,000 00			
Associate Professor	3,600 00			
Associate Professor	3,200 00			
Associate Professor	3,200 00			
Assistant Professor	2,600 00			
Assistant Professor	2,600 00			
Assistant Professor	2,500 00			
Assistant Professor	2,400 00			
Instructor	2,200 00			
Instructor	2,200 00			
Instructor	1,800 00			
Department of Civil Engineering:				
Professor	4,500 00			
Associate Professor	3,200 00			
Assistant Professor	2,800 00			
Assistant Professor	2,800 00			
Assistant Professor	2,600 00			
Assistant Professor	2,500 00			
Instructor	2,000 00			
Department of Mechanical Engineering:				
Professor	4,250 00			
Assistant Professor	2,800 00			
Assistant Professor	2,600 00			
Assistant Professor	2,400 00			
Instructor	2,400 00			
Instructor	2,200 00			
Instructor	2,200 00			
Instructor	2,000 00			
Instructor	2,000 00			
Instructor	1,900 00			
Instructor	1,800 00			
Instructor	2,200 00			
Shop Engineer	1,500 00			
Department of Electrical Engineering:				
Professor	4,500 00			
Associate Professor	3,200 00			
Associate Professor	3,200 00			
Instructor	2,000 00			
Graduate Assistant	800 00			
DIVISION OF LETTERS.				
Department of English:				
Professor	4,500 00			
Assistant Professor	3,400 00			
Assistant Professor	2,600 00			
Assistant Professor	2,600 00			
Assistant Professor	2,600 00			
Assistant Professor	2,400 00			
Assistant Professor	600 00			
Instructor	1,800 00			
Instructor	1,800 00			
Instructor	2,200 00			
Instructor	1,800 00			
Instructor	2,300 00			
Instructor	1,800 00			

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Department of Mathematics:				
Professor	$5,000 00			
Associate Professor	3,800 00			
Assistant Professor	3,300 00			
Assistant Professor	3,200 00			
Assistant Professor	2,400 00			
Instructor	2,200 00			
Instructor	2,100 00			
Instructor	1,800 00			
Instructor	1,800 00			
Department of Meteorology:				
Instructor	600 00			
Department of Military Science:				
Instructor	1,300 00			
Instructor	600 00			
Department of Music:				
Professor	3,500 00			
Instructor	1,350 00			
Instructor	1,200 00			
Instructor	600 00			
Department of Physical Training:				
Director	4,500 00			
Coach	4,500 00			
Assistant Director	3,100 00			
Instructor	2,200 00			
Instructor	2,000 00			
Instructor	1,800 00			
Instructor	2,500 00			
Instructor	2,500 00			
Instructor	2,500 00			
Department of Economics:				
Professor	4,500 00			
Associate Professor	3,800 00			
Associate Professor	3,600 00			
Associate Professor	3,600 00			
Assistant Professor	3,000 00			
Assistant Professor	3,600 00			
Department of History:				
Professor	5,000 00			
Assistant Professor	2,500 00			
Stenographer	675 00			
Department of Landscape and Design:				
Professor	4,500 00	$4,500 00		
Assistant in Landscape	800 00		$800 00	
Department of Federal Students	2,400 00			
Instructor	2,000 00			
Instructor	1,200 00			
Instructor	1,500 00			
Instructor	2,640 00			
Instructor	2,200 00			
Instructor	2,500 00			
Instructor	2,500 00			
DIVISION OF AGRICULTURE.				
Assistant to Dean	3,200 00	1,700 00	1,500 00	
Department of Animal Husbandry:				
Professor	4,250 00	2,850 00	1,400 00	
Assistant Professor	2,800 00	2,100 00	700 00	
Herdsman	1,800 00	1,800 00		
Stenographer	1,200 00	600 00		$600 00

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Department of Dairy Husbandry:				
Professor	$5,500 00	$4,500 00	$1,000 00	
Associate Professor	32,000 00	1,600 00	1,600 00	
Associate Professor	3,000 00	2,000 00	1,000 00	
Superintendent Testing	2,400 00	2,400 00		
Clerk	1,350 00	675 00	675 00	
Graduate Assistant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Clerk	1,200 00	1,200 00		
Assistant in Dairy	2,400 00		2,400 00	
Department of Farm Crops:				
Professor	5,000 00	3,500 00	1,500 00	
Associate Professor	4,200 00	1,200 00	3,000 00	
Assistant Professor	3,100 00	2,350 00	750 00	
Assistant Professor	2,400 00	2,200 00	200 00	
Instructor	2,500 00	700 00	1,800 00	
Research Assistant			600 00	
Research Assistant			500 00	
Instructor	2,200 00	1,500 00	700 00	
Graduate Assistant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Graduate Assistant	400 00	400 00		
Graduate Assistant	480 00	480 00		
Stenographer	1,300 00	650 00	650 00	
Assistant	2,300 00		800 00	
Assistant	2,400 00		2,400 00	
Assistant	3,200 00		1,000 00	$2,200 00
Department of Farm Mechanics:				
Professor	4,500 00	3,600 00	900 00	
Assistant	2,600 00	1,400 00	1,200 00	
Assistant	2,600 00	1,300 00	1,300 00	
Instructor	1,600 00	1,600 00		
Stenographer	600 00	600 00		
Department of Farm and Horses:				
Farm Foreman	3,000 00	3,000 00		
Department of Poultry:				
Associate Professor	3,200 00	2,400 00	800 00	
Foreman	1,600 00	1,600 00		
Stenographer		600 00		
Department of Forestry:				
Professor	5,000 00	4,000 00	1,000 00	
Assistant Professor	2,700 00	2,700 00		
Instructor	2,000 00	2,000 00		
Foreman	1,900 00	1,900 00		
Stenographer	1,350 00	1,350 00		
Department of Horticulture:				
Professor	5,500 00	3,000 00	2,500 00	
Associate Professor	3,500 00	2,000 00	1,500 00	
Associate Professor	3,400 00	1,700 00	1,700 00	
Assistant Professor	2,750 00	700 00	2,050 00	
Assistant Professor	2,600 00	2,000 00	500 00	
Assistant Professor	2,400 00	2,400 00		
Instructor	1,800 00	1,800 00		
Stenographer	1,350 00	675 00	675 00	
Research Assistant	3,000 00		3,000 00	
Assistant	3,600 00		1,800 00	1,800 00
Assistant	3,500 00		900 00	2,600 00
Assistant	1,400 00		1,400 00	

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Department of Soils:				
Professor	$5,000 00	$2,500 00	$2,500 00	
Associate Professor	3,600 00	1,800 00	1,800 00	
Assistant Professor	2,600 00	1,700 00	900 00	
Assistant Professor	3,200 00	800 00	1,600 00	$800 00
Instructor	2,000 00	1,400 00	600 00	
Graduate Assistant	800 00	800 00		
Graduate Assistant	800 00	800 00		
Research Associate	3,200 00		3,200 00	
Research Associate	3,800 00		3,800 00	
Assistant	3,400 00		2,200 00	1,200 00
Assistant	3,000 00		3,000 00	
Stenographer	1,350 00		675 00	675 00
Assistant	1,500 00		1,500 00	
Assistant	1,600 00		1,600 00	
Assistant	2,000 00		2,000 00	
pecial Courses:				
Instructor	2,000 00	2,000 00		
DIVISION OF VETERINARY SCIENCE.				
Department of Anatomy:				
Professor	4,200 00	4,200 00		
Assistant Professor	3,000 00	3,000 00		
Assistant Professor	2,800 00	2,800 00		
Stenographer	1,300 00	1,300 00		
Department of Pathology:				
Associate Professor	4,000 00	2,000 00	2,000 00	
Assistant Professor	2,600 00	2,600 00		
Department of Surgery and Clinic:				
Associate Professor	3,800 00	3,800 00		
Assistant Professor	2,600 00	2,600 00		
Instructor	2,400 00	2,400 00		
Experiment Station Chemistry:				
Chemist	4,500 00		4,500 00	
Research Associate	3,800 00		3,800 00	
Research Associate	3,200 00		3,200 00	
Research Associate	2,800 00		2,800 00	
Assistant	1,500 00		1,500 00	
Stenographer	675 00		675 00	
Bulletin Clerk	1,350 00		1,350 00	
DIVISION OF EXTENSION.				
Administration:				
Director	4,500 00			4,500 00
Assistant	2,800 00			2,800 00
Clerk	1,400 00			1,400 00
Stenographer	1,200 00			1,200 00
Home Demonstration Agents:				
Assistant State Leader	2,900 00			2,900 00
Assistant State Leader	1,800 00			1,800 00
Specialist	2,500 00			2,500 00
Specialist	3,000 00			3,000 00
Home Management	2,400 00			2,400 00
Stenographer	1,200 00			1,200 00
Rural Press Specialist:				
Specialist	1,500 00			1,500 00
Dairy Husbandry:				
Specialist	2,500 00			2,500 00
Assistant Specialist	2,500 00			2,500 00
Assistant Specialist	2,400 00			2,400 00
Specialist	3,000 00			3,000 00
Specialist	3,100 00			3,100 00
Specialist	2,400 00			2,400 00

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Farm Crops:				
Specialist	$2,100 00			$2,100 00
Specialist	3,100 00			3,100 00
Stenographer	1,300 00			1,300 00
Horticulture:				
Specialist	3,300 00			3,300 00
Stenographer	600 00			600 00
Potatoes and Vegetables:				
Specialist	3,000 00			3,000 00
Specialist	2,250 00			2,250 00
Stenographer	600 00			600 00
Animal Husbandry:				
Specialist	3,000 00			3,000 00
Control Insect Pests:				
Specialist	2,000 00			2,000 00
Specialist	2,000 00			2,000 00
Household Engineering:				
Specialist	3,200 00			3,200 00
Stenographer	600 00			600 00
Markets:				
Assistant Director	6,000 00			6,000 00
Assistant	4,000 00			4,000 00
Assistant	3,500 00			3,500 00
Stenographer	625 00			625 00
Poultry:				
Specialist	2,800 00			2,800 00
Assistant	2,000 00			2,000 00
Stenographer	600 00			600 00
Lecturer:				
Specialist	4,000 00			4,000 00
Land Clearing:				
Specialist	3,600 00			3,600 00
Assistant	2,600 00			2,600 00
Assistant	2,600 00			2,600 00
County Agents:				
Assistant State Leader	3,300 00			3,300 00
Assistant State Leader	3,000 00			3,000 00
Assistant State Leader	3,600 00			3,600 00
Stenographer	625 00			625 00
Stenographer	600 00			600 00
Stenographer	1,200 00			1,200 00
Agent, Alger County	1,200 00			1,200 00
Agent, Allegan County	1,200 00			1,200 00
Agent, Alpena County	1,200 00			1,200 00
Agent, Antrim County	1,200 00			1,200 00
Agent, Arenac County	1,200 00			1,200 00
Agent, Baraga County	1,200 00			1,200 00
Agent, Benzie County	1,200 00			1,200 00
Agent, Berrien County	1,200 00			1,200 00
Agent, Branch County	1,200 00			1,200 00
Agent, Calhoun County	1,200 00			1,200 00
Agent, Cass County	1,200 00			1,200 00
Agent, Charlevoix County	1,200 00			1,200 00
Agent, Cheboygan County	1,200 00			1,200 00
Agent, Clinton County	1,200 00			1,200 00
Agent, Crawford County	1,200 00			1,200 00
Agent, Delta County	1,200 00			1,200 00
Agent, Dickinson County	1,200 00			1,200 00
Agent, Eaton County	1,200 00			1,200 00
Agent, Emmet County	1,200 00			1,200 00
Agent, Genesee County	1,200 00			1,200 00
Agent, Gogebic County	1,200 00			1,200 00
Agent, Grand Traverse County	1,200 00			1,200 00
Agent, Gratiot County	1,200 00			1,200 00

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Counny Agents—*Continued*:				
Agent, Houghton County	$1,200 00			$1,200 00
Agent, Ingham County	1,200 00			1,200 00
Agent, Ionia County	1,200 00			1,200 00
Agent, Iosco County	1,200 00			1,200 00
Agent Iron County	1,200 00			1,200 00
Agent, Jackson County	1,200 00			1,200 00
Agent, Kalamazoo County	1,200 00			1,200 00
Agent, Kalkaska County	1,200 00			1,200 00
Agent, Kent County	1,200 00			1,200 00
Agent, Lapeer County	1,200 00			1,200 00
Agent, Lenawee County	1,200 00			1,200 00
Agent, Livingston County	1,200 00			1,200 00
Agent, Luce County	1,200 00			1,200 00
Agent, Macomb County	1,200 00			1,200 00
Agent, Manistee County	1,200 00			1,200 00
Agent, Marquette County	1,200 00			1,200 00
Agent, Mason County	1,200 00			1,200 00
Agent, Mecosta County	1,200 00			1,200 00
Agent, Midland County	1,200 00			1,200 00
Agent, Monroe County	1,200 00			1,200 00
Agent, Montcalm County	1,200 00			1,200 00
Agent, Muskegon County	1,200 00			1,200 00
Agent, Newaygo County	1,200 00			1,200 00
Agent, Oakland County	1,200 00			1,200 00
Agent, Oceana County	1,200 00			1,200 00
Agent, Ogemaw County	1,200 00			1,200 00
Agent, Ontonagon County	1,200 00			1,200 00
Agent, Osceola County	1,200 00			1,200 00
Agent, Otsego County	1,200 00			1,200 00
Agent, Presque Isle County	1,200 00			1,200 00
Agent, Saginaw County	1,200 00			1,200 00
Agent, Sanilac County	1,200 00			1,200 00
Agent, Schoolcraft County	1,200 00			1,200 00
Agent, Shiawassee County	1,200 00			1,200 00
Agent, St. Clair County	1,200 00			1,200 00
Agent, St. Joseph County	1,200 00			1,200 00
Agent, Tuscola County	1,200 00			1,200 00
Agent, Van Buren County	1,200 00			1,200 00
Agent, Washtenaw County	1,200 00			1,200 00
Agent, Wayne County	1,200 00			1,200 00
Agent, Wexford County	1,200 00			1,200 00
Boys' and Girls' Club Work:				
State Leader	2,000 00			2,000 00
Assistant State Leader	3,000 00			3,000 00
Assistant	1,800 00			1,800 00
Assistant	2,600 00			2,600 00
Assistant	2,500 00			2,500 00
Stenographer	1,200 00			1,200 00
Stenographer	1,200 00			1,200 00
Assistant	2,800 00			2,800 00
Agent, Barry County	600 00			600 00
Agent, Branch County	600 00			600 00
Agent, Calhoun County	600 00			600 00
Agent, Cheboygan County	600 00			600 00
Agent, Hillsdale County	600 00			600 00
Agent, Iron County	600 00			600 00
Agent, Jackson County	600 00			600 00
Agent, Lenawee County	600 00			600 00
Agent, Livingston County	600 00			600 00
Agent, Macomb County	1,000 00			1,000 00
Agent, Oakland County	600 00			600 00
Agent, Van Buren County	600 00			600 00
Agent, Washtenaw County	600 00			600 00
Agent, Wayne County	600 00			600 00

TABLE NO. 13.—*Continued.*

	Rate per year	Classification		Extension
		Current	Experiment Station	
Home Demonstration Agents:				
Stenographer—	$600 00			$600 00
Agent, Ironwood County	1,000 00			1,000 00
Agent, Kalamazoo County	1,000 00			1,000 00
Agent, Marquette County	1,000 00			1,000 00
Agent, Oakland County	1,000 00			1,000 00
Agent, Ottawa County	400 00			400 00
Agent, Allegan County	1,000 00			1,000 00
Agent, Wayne County	1,000 00			1,000 00
Vocational Teachers Training:				
Professor	5,000 00			5,000 00
Associate Professor	3,200 00			3,200 00
Associate Professor	3,200 00			3,200 00
Professor	4,500 00			4,500 00
Instructor	2,800 00			2,800 00
Instructor	2,600 00			2,600 00
Stenographer	1,350 00			1,350 00

Salaries Experiment Station, Fiscal Year Ending June 30, 1923.

Director	$2,523 35
Assistant to Director	1,500 00
Stenographer	550 50
Bacteriologist	1,600 00
Research Associate in Bacteriology	1,600 00
Research Associate in Bacteriology	2,199 80
Research Associate in Bacteriology	799 90
Research Associate in Bacteriology	3,600 00
Research Associate in Bacteriology	2,800 00
Research Associate in Bacteriology	3,115 70
Assistant in Bacteriology	1,600 00
Assistant in Bacteriology	252 80
Botanist	900 00
Research Assistant in Plant Pathology	1,900 05
Research Assistant in Physiology	2,432 60
Research Assistant in Botany	2,400 00
Research Assistant in Plant Pathology	2,116 06
Research Assistant in Botany	353 80
Chemist	4,500 05
Research Associate in Chemistry	3,800 20
Research Associate in Chemistry	3,200 00
Assistant in Chemistry	2,800 05
Stenographer	675 00
Assistant in Farm Crops	200 00
Field Foreman Farm Crops	401 00
Animal Husbandman	1,400 00
Research Assistant in Animal Husbandry	700 00
Dairy Husbandman	1,000 00
Research Associate in Dairying	1,000 00
Research Associate in Dairying	367 00
Research Assistant in Dairying	2,400 00
Research Associate in Dairying	1,600 00
Entomologist	1,500 00
Research Associate in Entomology	1,957 90
Research Assistant in Entomology	1,400 00
Farm Crops Experimenter	1,500 00
Research Associate in Plant Breeding	3,000 05
Research Associate in Farm Crops	750 00
Assistant in Farm Crops	800 00
Research Assistant in Farm Crops	1,800 00
Farm Crops Experimenter	2,400 00
Research Assistant in Farm Crops	700 00
Farm Mechanics Experimenter	900 00
Assistant in Farm Mechanics	1,300 00
Assistant in Farm Mechanics	1,200 00
Forester	1,000 00
Assistant in Horticulture	1,425 00
Research Associate in Horticulture	3,000 05
Assistant in Horticulture	500 00
Poultry Husbandman	800 00
Soil Physicist	2,500 00
Research Associate in Soils	3,200 00

Salaries Experiment Station, Fiscal Year Ending June 30, 1923—Continued

Research Associate in Soils	$1,749 50	
Research Professor in Soils	3,800 10	
Research Associate in Soils	2,200 00	
Research Assistant in Soils	3,000 00	
Librarian	400 00	
Secretary	500 00	
Treasurer	500 00	
Bookkeeper	400 00	
Bulletin Clerk	1,350 00	
Stenographer	675 00	
Stenographer	675 00	
Stenographer	450 00	
Stenographer	650 00	
Stenographer	672 90	
Research Associate in Animal Pathology	2,000 00	
Assistant in Horticulture	900 00	
Research Associate in Horticulture	1,407 30	
Assistant in Soils	1,600 00	
Research Associate in Soils	1,600 00	
Research Associate in Soils	600 00	
Assistant in Plant Pathology	2,366 00	
Assistant in Soils	2,034 00	
Stenographer	791 60	
Research Assistant in Horticulture	1,936 30	
Research Assistant in Soils	900 00	
Research Assistant in Farm Crops	915 80	
Superintendent, Graham Horticulture Experiment Station	2,100 00	
Superintendent, Upper Peninsula Experiment Station	2,284 70	
Research Associate in Horticulture	1,413 60	
Horticulturist	2,078 70	
Assistant in Soils	1,500 00	
Graduate Assistant in Botany Experiment Station	802 27	
Assistant in Chemistry	1,125 00	
Research Assistant in Horticulture	450 00	
Research Assistant in Horticulture	375 00	
Assistant in Chemistry	303 20	
Superintendent, South Haven Experiment Station	700 00	
Assistant in Soils	600 40	
Assistant in Soils	450 31	
Assistant in Soils	450 31	
Graduate Assistant in Landscape Gardening	665 20	
Assistant in Chemistry	496 30	
Associate in Horticulture	301 65	
Total		$138,191 10

TABLE NO. 14.—*Income from all outside sources from date of foundation.*

Year	From State Legislature			From U. S. Congress				Total
	For current expenses	For special purposes	Land sales salt spring and swamp land grants	Morrill act of 1862, interest from land grant and trespass	Hatch act of 1887, and Adams act of 1906 experiment station	Morrill act of 1890, supplementary endowment	Smith-Lever Act of 1914 Extension	
1855			$56,320 00					$56,320 00
1856								
1857	$40,000 00							40,000 00
1858								
1859	37,500 00							37,500 00
1860								
1861	6,500 00		152 25					6,652 25
1862	10,000 00		218 97					10,218 97
1863	9,000 00		407 80					9,407 80
1864	9,000 00		726 09					9,726 09
1865	15,000 00		1,156 61					16,156 61
1866	15,000 00		1,094 27					16,094 27
1867	20,000 00		7,608 38					27,608 38
1868	20,000 00		592 49					20,592 49
1869	20,000 00	$30,000 00	17,559 00	$58 96				67,617 96
1870	20,000 00		1,320 02	2,720 93				24,040 95
1871	18,250 00	10,500 00	4,135 72	3,785 54				36,671 26
1872	18,250 00	3,000 00	217 05	7,175 65				28,642 70
1873	21,796 00	15,602 00	10 13	11,059 06				48,467 19
1874	13,000 00	15,602 00	150 13	14,061 98				42,814 11
1875	7,638 00	7,755 50	144 53	14,446 14				29,984 17
1876	7,638 00	6,755 50	1,773 09	16,830 17				32,996 76
1877	6,150 00	30,686 80	979 06	15,172 86				52,988 72
1878	6,150 00	5,686 80	826 60	15,807 09				28,470 49
1879	4,971 80	16,068 32	712 22	16,978 22				38,730 56
1880	4,971 80	7,068 32	797 55	17,837 24				30,674 91
1881	7,249 00	43,720 50	461 95	20,935 25				72,366 70
1882	7,249 00	8,945 50	358 46	22,507 45				39,060 41
1883	8,385 00	23,793 00	391 95	30,749 60				63,319 52
1884	8,385 00	10,526 00	1,259 90	27,909 72				48,080 65
1885		35,103 00	187 50	29,770 40				65,060 90
1886		22,617 00		30,461 04				53,078 04
1887		*44,040 00	198 20	†24,611 37				68,849 57
1888		30,752 50	144 20	32,406 60	$15,000 00			78,303 30
1889		*20,973 00	10 50	31,322 69	15,000 00			67,306 19
1890		*27,172 00	238 50	32,360 64	15,000 00	$15,000 00		89,771 14
1891		22,947 50	37 38	34,750 54	15,000 00	16,000 00		88,735 42
1892		22,947 50	137 38	34,948 12	15,000 00	17,000 00		90,033 00
1893		18,862 50	10 50	37,927 04	15,000 00	18,000 00		89,800 04
1894		18,862 50	433 59	44,527 26	15,000 00	19,000 00		97,823 35
1895		‡19,000 00	10 50	45,301 85	15,000 00	20,000 00		99,312 35
1896		‡16,000 00		43,886 40	15,000 00	21,000 00		95,886 40
1897		§17,700 00		43,779 54	15,000 00	22,000 00		98,479 54
1898		‖17,500 00		47,508 28	15,000 00	23,000 00		103,008 28
1899		¶8,750 00	705 00	52,526 11	15,000 00	24,000 00		100,981 11
1900		¶72,500 00	175 00	72,298 38	15,000 00	25,000 00		184,973 38
1901††		¶72,500 00		63,976 79	15,000 00	25,000 00		176,476 79
1902	100,000 00	**1,000 00		64,081 81	15,000 00	25,000 00		205,081 81
1903	100,000 00	**1,000 00		65,573 90	15,000 00	25,000 00		206,573 90
1904	100,000 00	**1,000 00	61 19	67,312 37	15,000 00	25,000 00		208,373 56
1905	100,000 00	*81,000 00		72,035 32	15,000 00	25,000 00		293,035 32
1906	157,810 00	*15,000 00		70,286 56	15,000 00	25,000 00		283,096 56
1907	173,410 00	**1,000 00		70,155 22	23,691 60	25,000 00		293,256 82
1908	173,410 00	**1,000 00		70,385 79	23,326 10	30,000 00		298,121 89
1909	173,410 00	**1,000 00		69,527 13	26,000 00	35,000 00		304,937 13
1910	173,410 00	**1,000 00		71,109 49	28,000 00	40,000 00		313,519 49
1911	173,410 00	**1,000 00		70,304 15	30,000 00	45,000 00		319,714 15
1912	228,800 00	**1,000 00		70,265 32	30,000 00	50,000 00		380,065 32
1913	228,800 00	**1,000 00		70,289 30	30,000 00	50,000 00		380,089 30
1914	228,800 00	**1,000 00		71,324 94	30,000 00	50,000 00		381,124 94
1915	308,147 25	**1,000 00		70,385 46	30,000 00	50,000 00	$10,000 00	469,532 71
1916	560,000 00	**1,000 00		71,391 56	30,000 00	50,000 00	28,032 37	740,423 93
1917	560,000 00	**1,000 00		69,437 43	30,000 00	50,000 00	43,059 35	753,496 78
1918	560,000 00	**1,000 00		70,502 10	30,000 00	50,000 00	58,086 33	769,588 43
1919	560,000 00	**1,000 00		70,662 44	30,000 00	50,000 00	73,113 31	784,775 75
1920	900,000 00	***35,000 00		70,736 34	30,000 00	50,000 00	133,221 23	1,218,957 57
1921	900,000 00	***35,000 00		70,685 37	30,000 00	50,000 00	148,172 80	1,233,858 17
1922	1,000,000 00			70,838 32	30,000 00	50,000 00	151,585 39	1,302,423 71
1923	1,000,000 00			70,618 98	30,000 00	50,000 00	159,913 95	1,310,532 93
Totals	$8,821,490 85	$905,937 74	$101,723 66	$2,478,308,21	$776,017 70	$1,145,000 00	$805,184 73	$5,033,662 89

*Including appropriation for weather service.
†October 1, 1886, to June 30, 1885, nine months.
‡Including $5,000 for institutes and $1,000 for weather service.
§Including $5,500 for institutes and $1,000 for weather service.
‖Including $2,750 for institutes and $500 for weather service
††To June 30.
**Weather service.
¶Including $5,500 for institutes and $1,000 for weather service.
***Extension.

TABLE NO. 15.—*Summary of College Inventory, June 30, 1922.*

DIVISION OF BUILDINGS AND LANDS:	
Department of Buildings and Lands.	
Buildings and Lands:	
College farm and park, 671 acres	$67,100 00
Lot 2, 3 and 4 River Bend addition	4,000 00
Athletic field and drive, 13 acres	1,300 00
320 acres swamp land	960 00
Purchased C. D. Woodbury farm, 1916, 308.82 acres	38,602 50
1 acre, more or less, formerly belonging to Harrison, adjacent to campus	2,000 00
Purchased in 1913, 27 acres	3,375 00
50,359 acres, remainder of land grant not formerly carried in inventory.	251,795 00
Buildings:	
Library and museum, built in 1881	22,000 00
Wells Hall, rebuilt 1905-06	55,000 00
Abbott Hall, built 1888, addition in 1896	15,000 00
Chemical laboratory, built in 1871, south end addition in 1881, east end addition in 1911	35,000 00
Veterinary laboratory, built in 1885	5,000 00
Horticultural laboratory, built 1888	7,000 00
Entomological laboratory, built 1889, improved 1897	7,500 00
Botanical laboratory, built 1892, improved 1909	20,000 00
Armory, built 1885	6,000 00
Greenhouse and stable, built 1873, 1879, rebuilt 1892, 1902	6,000 00
President's and two frame dwellings, built 1874	12,000 00
Six brick dwellings, built 1857, 1879 and 1884	18,000 00
One frame house, built 1885	3,500 00
Howard Terrace dwelling, built 1888	13,000 00
Farm house dwelling, built 1869	2,000 00
Bull barn, rebuilt 1905	1,500 00
Sheep barn, rebuilt 1906	2,500 00
Horse barn, built 1906	5,000 00
Grade herd barn, rebuilt 1905	4,000 00
Piggery, rebuilt 1907	1,500 00
Dairy barn, rebuilt 1900	4,000 00
Poultry house, built 1906	1,000 00
Incubator house, built 1906	500 00
Poultry house, built 1907	1,500 00
Three poultry houses, built 1907	300 00
Ten brooder houses, built 1908	250 00
Corn barn, built 1878	400 00
Observatory, built in 1880	100,00
Bath house and fittings, built 1902-03	17,000 00
Hospital, built 1894	3,000 .00
Waiting room and book store, built 1902	1,700 00
One silo	200,00
Women's building, built 1909	91,000 00
Forestry building, built 1900	15,000 00
Bacteriological building, built 1902	27,000 00
Power house, built 1904	25,000 00
Tunnel system, built 1904	45,000 00
Cold storage, rebuilt 1905	2,000 00
Iron bridge over Cedar River, built 1888	1,500 00
Bridge to athletic field	500 00
Manure shed	600 00
Four hospital cottages, built 1909	6,000 00
Agricultural building, built 1909	182,000 00
Tile Silo, No. 1	500 00
Piggery for serum production	1,000 00
Two tenant dwellings, built 1912	2,400 00
New Dairy building, built 1913	55,000 00
Tile silo, No. 2	600 00
Tile silo No. 3	600 00
2 cement stave silos	800 00
Forestry packing house	1,000 00
Veterinary laboratory, 1914	33,000 00
Special chemical laboratory	800 00
R. E. Olds Hall of Engineering, 1916	155,000 00
Shop No. 1, built 1916	26,400 00
Shop No. 2, built 1916	15,750 00
Shop No. 3, built 1916	14,500 00
Gymnasium, built 1906	220,000 00
Shops and storehouse, built 1919 and 1920	34,000 00
Boiler house, built 1921	153,000 00
Coal pit, built 1921	900 00
Entomological laboratory, 1921	3,400 00
Addition to poultry house	1,800 00
Total	$1,756,632 50

INVENTORY—*Concluded*

DIVISION OF AGRICULTURE:	
Department of Agricultural Education	$630 25
Department of Animal Husbandry	22,237 65
Department of Dairy Husbandry	48,344 61
Office of Dean of Agriculture	1,245 21
Department of Farm Crops	3,797 12
Department of Farm and Horses	30,154 19
Department of Farm Management	550 86
Department of Farm Mecanics	7,165 73
Department of Forestry	21,148 20
Department of Horticulture	6,207 87
Department of Poultry Husbandry	10,898 19
Department of Soils	9,122 15
DIVISION OF APPLIED SCIENCE:	
Department of Bacteriology	19,557 09
Department of Botany	28,572 94
Department of Chemistry	68,369 28
Department of Entomology	12,378 66
Department of Meteorology	263 27
Department of Physiology and Zoology	33,874 21
Department of Physics	14,040 48
DIVISION OF ENGINEERING:	
Department of Civil Engineering	21,478 35
Department of Drawing and Design	10,123 98
Department of Electrical Engineering	26,497 59
Department of Mechanical Engineering	87,744 22
Office of Dean of Engineering	2,924 37
DIVISION OF EXPERIMENT STATION:	
Section of Bacteriology	13,477 99
Section of Botany	8,033 72
Section of Buildings and Lands	88,175 00
Bulletin Room	2,575 21
Section of Chemistry	14,932 58
Office of the Director	637 12
Section of Entomology	8,747 43
Section of Farm Crops	2,177 45
Section of Farm Management	1,290 24
Section of Graham Horticultural Station	4,118 40
Section of Horticulture	2,026 05
Section of Soils	6,243 49
Section of South Haven Experiment Station	1,970 09
Section of Upper Peninsula Experiment Station	20,199 52
Library	10,202 90
DIVISION OF EXTENSION	12,836 62
DIVISION OF HOME ECONOMICS	31,085 93
DIVISION OF LETTERS:	
Department of Economics	294 40
Department of English	1,440 69
Department of History and Political Science	1,002 15
Department of Military Science	9,917 53
Department of Mathematics	865 50
Department of Music	2,435 00
Department of Physical Training	15,550 30
DIVISION OF VETERINARY SCIENCE:	
Department of Anatomy	21,327 56
Dean's Office	2,406 96
Department of Pathology	7,530 19
Department of Surgery and Medicine	4,164 43
MISCELLANEOUS:	
Office of Alumni Recorder	1,025 89
Carpenter shop	5,873 10
Fire Department	9,389 55
Health Service	5,768 58
Library	84,616 36
Paint shop	717 33
Post office	1,383 21
Office of President	1,500 98
Office of Purchasing Agent	686 71
Office of Registrar	1,558 40
Office of Secretary	5,611 21
Store	43,822 95
Vocational Teacher Training	690 37
Water, heat and light	109,379 33
Total	$1,055,014 89
Division of Building and Lands	1,756,632 50
Grand Total	$2,811,647 39

REPORT OF THE DEAN OF AGRICULTURE.

To the President:

Sir:—The following reports of the various department heads give, in an excellent manner, the progress and service of the Agricultural Division for the year.

The educational work of the Agricultural Division has been conducted in a manner which has maintained the high standards of previous years. One of the outstanding developments in the Agricultural Division has been the development of a strong Graduate School of forty-five students. The members of this Graduate School are largely from other states and nations. The graduates of our own institution, however, are found in many of the departments. The development of this Graduate School means a good deal to our future prestige in agricultural education work.

The following statistics present a classified statement of the enrollment of the Division during the year:

Advanced Degree		10
Graduate Students		45
Graduating Class	(116)	
Seniors		124
Juniors		96
Sophomores		131
Freshmen		179
Specials		4
Summer Session (regular)		131
Special Agricultural Course—School Superintendents		11
		731

Vocational Guidance—Federal men	88
Sixteen Weeks' Course in General Agriculture first year	52
Sixteen Weeks' Course in General Agriculture second year	19
Eight Weeks' Course in General Agriculture first year	23
Eight Weeks' Course in General Agriculture second year	8
Eight Weeks' Course in Horticulture	25
Eight Weeks' Course in Farm Engineering	9
Twelve Weeks' Course in Dairy Production	28
Twelve Weeks' Course in Dairy Manufacture	12
Eight Weeks' Course in Poultry Husbandry	18
Two Week's' Course in Ice Cream Making	7
First Truck and Tractor Course	7
Second Truck and Tractor Course	5
Third Truck and Tractor Course	4

Fourth Truck and Tractor Course	8
Special Courses	4
	317
Total	1,048

One noticeable feature of this year's work is the increased interest of farmers in the Agricultural College. This is evidenced (1) by the increased demands for speakers for agricultural meetings; (2) by the great increase in correspondence on agricultural subjects; and (3) by the large number of farmers who have visited the institution during the year.

Over fifty agricultural groups or organizations with a total attendance of over 13,000 people have visited the college during this period. These people had a very splendid attitude toward the institution and as a result of these visits, they will become still stronger supporters of M. A. C. The two outstanding meetings of the year were Farmers' Week on January 29 to February 2, and the 5th Annual Farmers' Day, July 27.

This year, for the first time, the annual meeting of the State Livestock Breeders and Feeders' Association was combined with Farmers' Week. The result was quite satisfactory and will be repeated next year.

During the year, the division again entered competitions with poultry, dairy, and stock judging teams at national and international expositions, making credible winnings. The Poultry team, in their contest, had the distinction of having the high man of all contestants.

For the first time in the history of the institution, a fruit judging team competed at the National Fruit Show at Council Bluffs, Iowa. The team won second place honors at this show.

The institution had a very large and credible exhibit of horses, beef cattle, sheep, and swine at the 1922 International Livestock Exposition.

Through the effective and harmonious work of the various departments, the high standard and service of the Division has been maintained throughout the year.

Respectfully submitted,
E. B. HILL,
Asssitant to the Dean of Agriculture.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

To the President:

Sir:—I have the honor to submit the following report of the Department of Animal Husbandry for the year ending June 30, 1923.

The following table gives a summary of the teaching work carried by the staff the past year:

Subject	Sect.	Days per week	Hours per week	No. in class	Instructor
Fall Term:					
Regulars. .					
A. H. 1	1–4	3	5	74	W. E. J. Edwards
A. H. 1	5–8	3	5	40	G. A. Brown
A. H. 1	9–12	3	5	73	W. E. J. Edwards
A. H. 2		3	5	42	W. E. J. Edwards
A. H. 5		5	8	33	G. A. Brown
Short Course:					
Beef Cattle Management		3	4	19	W. E. J. Edwards
Types of Livestock		5	10	50	W. E. J. Edwards
Animal Feeding		5	5	52	G. A. Brown
Types of Livestock		4	8	26	H. J. Gallagher
Federal.					
Types of Livestock		3	6	45	H. J. Gallagher
Winter Term:					
Regulars.					
A. H. 6	1	5	8	15	G. A. Brown
A. H. 6	2	3	8	15	G. A. Brown
Short Course.					
Animal Feeding		5	5	24	G. A. Brown
Breeds		5	8	46	W. E. J. Edwards
Types		5	10	24	W. E. J. Edwards
Swine Breeding and Managem't.		3	4	40	W. E. J. Edwards
Livestock Judging		5	10	9	R. L. Mackie
Spring Term:					
Regulars.					
A. H. 7		3	7	18	G. A. Brown
A. H. 4b		3	3	26	G. A. Brown
Federal.					
A. H.		3	6	31	H. J. Gallagher

We were extremely fortunate in being able to obtain Mr. Gallagher to assist in the teaching work, which otherwise could not have been handled by the members of the Department.

EXTENSION.

Mr. V. A. Freeman has been conducting extension work during the past year. His time has been very largely devoted to work with swine, for which there has been an urgent demand, especially in the southern counties of the State.

LIVE STOCK EQUIPMENT.

The livestock equipment has been very materially strengthened and improved during the past year. The Shorthorn herd has been improved by the purchase of seven cows, all of them excellent individuals. The Herefords have been added to by the purchase of a herd sire at the last International and two females from Crapo Farm at Swartz Creek, Michigan.

With the sheep, a new Oxford sire was purchased from Mr. D. P. Beasore of Eaton Rapids, a new Hampshire from Mr. Cherry of Xenia, Ohio, and a new Southdown ram was purchased from the United States Department of Agriculture.

The swine equipment was strengthened by the purchase of two Berkshire sows and a sire from Parker Brothers of Niles, Michigan, the Poland China herd by the purchase of animals from Witt Brothers of Adrian, Harry Cobb of Stockbridge and A. D. Gregory of Ionia.

At the present time the herds and flocks are in very favorable condition, although the purchase of some better females for the Hereford cattle herd would be desirable, were the funds available for the same.

The Department was extremely fortunate in that a new steer feeding shed was constructed last summer, materially relieving the congestion in the beef barn. The completion of the new Piggery and the turning over of a larger area of ground than had hitherto been available has greatly facilitated the work with swine, making it possible to give the herd better care and at the same time carry on more experimental work.

LIVE STOCK EXHIBITS.

An exhibit of beef cattle and fat wethers was made at the State Fair, where we won first prize steer herd and second prize on the Hereford and Aberdeen Angus herd sires. The most extensive exhibit of livestock ever put out by the College was made at the 1922 International.

Thirteen steers, including Shorthorns, Herefords and Aberdeen-Angus, were shown, winning six premiums in stiff competition. In the grades and cross-breds, a grade Shorthorn senior calf won second place in a class of 26, and in the Aberdeen-Angus junior calf class, Blackbird Brandon 2nd won third place. Both the Aberdeen-Angus and Hereford Steer herds won fifth prize, ten herds being shown in each class.

With thirty-two hogs entered in the barrow classes, twenty-nine premiums were won, among these being six firsts, two championships and one reserve championship. In the 350 to 450 lbs. Tamworth barrow class, first, second and third premiums were taken, the first prize hog, "Michigan Buster," being later made champion of the breed. These three barrows also won first as pen and were later made champion pen. In the 450 to 550 lbs. Berkshire barrow class, "Michigan Chief" was given first premium and later the reserve championship. This barrow, with two others, won second in the pen class. In the 300 to 400 lbs. carcass class, all prizes offered, first, second and third, were taken by M. A. C. entries. The first prize, a Chester White, won third in his class on foot; the second prize, a Berkshire, was the reserve champion Berkshire barrow of the show; and the third prize in the carcass class was also won by a Berkshire that took second place in his class.

Thirty-three sheep were shown and twenty-one premiums won. In the Rambouillet yearling ewe class, first premium was won in a class of fifteen. This ewe was later awarded the championship of the breed. At the 1921 International she was awarded first in the ewe lamb class. The showing of Shropshire wethers was very strong. In a class of twenty-four wether lambs, third place was won, while in the Hampshire wether lamb class, first place was won. The Oxford wether lambs showed to good advantage, winning first, second and third premiums, these same lambs winning first in the pen class.

ACKNOWLEDGMENTS.

I desire to express my sincere appreciation of the assistance which Mr. Edwards has given in instruction work, Mr. Mackie in managing the herds and flocks, and Mr. Walker in fitting show cattle.

Respectfully submitted,
GEO. A. BROWN,
Professor of Animal Husbandry.

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY.

To the President:—

Sir:—I herewith submit the report for the Department of Dairy Husbandry for the year ending June 30, 1923

The personnel of the Department has been as follows:

O. E. Reed, Professor of Dairy Husbandry.
J. E. Burnett, Associate Professor of Dairy Husbandry.
O. T. Goodwin, Associate Professor of Dairy Manufactures.
Resigned, May 10, 1923.
P. S. Lucas, Associate Professor of Dairy Manufactures.
E. B. Hint, Superintendent of Official Testing.
C. F. Huffman, Research Assistant in Dairying.
H. C. Jordan, Instructor in Cheese Making.
January 1st—March 1st, 1923.
W. J. Sweetman, One-fourth time Assistant.
R. R. Palmer, One-half time Assistant.
R. J. Werdon, One-half time Assistant.

THE DAIRY HERD.

The dairy herd owned by the College, has been used more for instructional and experimental purposes than ever before in its history. The herd has just about held its own in numbers this year. The value of the cattle has been increased by making better records. A large number of official seven-day and yearly records have been made. The cow, Pauline Segis Fayne 551402, completed her yearly record as a two-year-old and produced 21,064.2 pounds of milk and 819.27 pounds of 80 per cent butter in a year. This record was the highest record in the state for this age for the Holstein breed. She has also produced 684.2 pounds of milk in seven days and 2,960.6 in 30 days, which are State records for milk production. Pauline Jane Pontiac, a four-year-old heifer, bred by the College, produced 731.1 pounds of milk and 36.59 pounds of butter in seven days. At the time this record was completed, it was the highest record ever made by any agricultural college in the United States. It is interesting to note that this cow, as well as her grandmother, was bred by the College. Another Holstein cow, College Segis Jane, produced 32.97 pounds of 80 per cent butter in seven days.

Four Guernsey two-year-old cows finished yearly records, all making above 500 pounds of butterfat.

During the past year we have established the foundation for an Ayrshire herd at this institution by the purchase of four two-year-old Ayrshire heifers from Alta Crest Farms, Spencer, Massachusetts. This firm also donated to the Agricultural College a bull calf out of an imported cow and sired by the champion show bull of the United States. This institution has not had any representatives of this breed for a number of years, but it is deemed necessary that we establish this foundation so that our students will have the advantages of studying these cattle along with the other breeds.

EXTENSION SERVICE.

Much time has been spent by the members of the Department in administering the dairy extension work. A number of men have been added to the dairy extension staff on account of the heavy demand for organization and dairy information. The staff includes H. E. Denison, Specialist in Charge; A. C. Baltzer, Specialist in Charge of Cow Testing Associations; and S. J. Brownell, Specialist in Charge of Bull Associations. Other specialists are R. H. Addy, Karl H. Miller, Jr., and J. G. Hays. Mr. Hays is employed jointly by the College and the Michigan Holstein Association. A new policy has been adopted in establishing greater co-operation between the College and Breeders' Association in carrying out the dairy extension program. The Michigan Holstein Association is the first association to enter into this joint arrangement. The Holstein Breeders' organization pays the salary of Mr. Hays and the Extension Division pays his traveling expenses. He spends his time in doing general extension work for the College and Holstein breed extension for the Association. By this arrangement the Extension service in the State is co-ordinated and centralized at the College. This arrangement, judging from the results obtained thus far, is highly desirable and other breed associations will undoubtedly co-operate with the college on the same basis.

In addition to the men mentioned above, much time has been spent by the members of the Department in attending meetings and doing expert service and judging at County Fairs.

County campaigns, established by the Department in the Fall of 1921, have been continued and during the past year campaigns have been carried out in the following counties: Kent, Gratiot, Clinton, Washtenaw, Livingston, Genesee, Macomb, Charlevoix, Emmet, Delta, Marquette, Ontonagon, and several other districts throughout the State. The campaigns have been highly successful. While it is difficult to gauge results in a concrete form, any one who is familiar with the work at all knows that there is a great deal of good accomplished by putting on these intensive campaigns, giving out information on the best possible methods used in putting the dairy industry on a more efficient basis.

One measure of the extension work during the past year is shown by the fact that on June 30, 1922 there were 17 cow testing associations in operation and on June 30, 1923 there were 60 associations organized and 56 in active operation. There has been a great increase in the interest as well as the number of cow testing associations during the past year. While this work has been started in the State for some time, it has not been developed to a very great extent until the past year. There is now a very heavy demand for associations to be organized in every county and if the present force can possibly do the work, there is no question but there will be more than 100 cow testing associations in operation in another year.

More than 100 pure bred bulls have been placed by members of the staff and a large number of co-operative bull associations have been organized.

ADVANCED REGISTRY WORK.

The amount of official testing work conducted this year compared with that conducted the previous year, shows a decrease. This year there were 893 seven day records on Holstein Friesian cattle forwarded to Mr. Gardner's office and 218 records which were not forwarded to Mr. Gardner, due to the fact the cows did not equal their previous record, or not high enough so that the owners wished to have them reported. There were 149 thirty day records and about 40 thirty pound records. The previous year there 1,230 seven day records, 183 thirty day records, and 42 thirty pound records.

Semi-official or yearly work was carried on in herds of the various breeds throughout the state as follows:

Breed	Number of Herds
Holstein-Friesian	27
Jersey	19
Guernsey	23
Ayrshire	2
Brown Swiss	1

The Honor List published by the Holstein-Friesian Association of America includes 141 Michigan records, or 9.19% of the total number on the Honor List. This includes the world's milk record for seven days in the junior 4 year old class, and American record for thirty days milk in the junior 4 year old class. There have also been several State records made, divided among the Jersey, Guernsey and Holsteins.

The offices of the Dairy Department have been moved from the Agricultural Building to the Dairy Building and the space that was not previously occupied has been fitted up as offices and the Department is now housed in a very satisfactory manner.

Respectfully submitted,
O. E. REED,
Professor of Dairy Husbandry.

REPORT OF THE DEPARMENTS OF FARM CROPS.

To the President,

Sir:—I take pride in reporting a year of progress in our instructional work. Opportunity was offered for the development of newly established courses. The presence of additional graduate students greatly increased the strength of the laboratory work supporting each course. The following courses were presented by the department:—

Farm Crops 1—Cereals.—A required Freshman Course. Two-hour lecture and two-hour laboratory periods per week. Three credits. 162 students.
J. F. Cox, J. R. Duncan, and Assistants.

Farm Crops 2—Forage Crops.—A required Sophomore Course. Two-hour lecture and two-hour laboratory periods per week. Two credits. 91 students.
C. R. Magee, W. H. Hosterman.

Farm Crops 3—Advanced Cereals, Grain Judging and Marketing for Seniors.—Four laboratory and three lectures. Five credits. Twenty-six students.
G. W. Putnam, C. E. Cormany, and Assistants.

Farm Crops 4—Advanced Forage Crops.—Three lectures and two laboratory periods. Five credits. Twenty-six students.
C. R. Megee, C. E. Cormany, and Assistants.

Farm Crops 5a—Applied Genetics.—(For Seniors).—Three hour lecture and two laboratory periods. Five credits. Three students.
F. A. Spragg.

Farm Crops 5b—Advanced Plant Genetics.—(For Seniors).—Three-hour lecture and two laboratory periods. Five credits. Five students.
F. A. Spragg and Graduate Assistants.

Farm Crops 6—Crop Adaptations and Rotations.—(For Seniors).—Three lecture and two laboratory periods. Five credits. Twenty-six students.
J. F. Cox, G. W. Putnam, H. R. Pettigrove.

Farm Crops 7—Potatoes, Sugar Beets and Minor Root Crops.—(For Juniors.—Two lecture and one laboratory periods. Three credits. Thirty-four students.
C. E. Cormany and Graduate Assistants.

Short Course—Farm Crops A.—16 weeks. Forty-eight students.
C. R. Megee, C. E. Cormany.

Farm Crops B.—16 weeks. Fourteen students.
C. R. Megee, C. E. Cormany.

Farm Crops A.—8 weeks. Twenty-four students.
C. R. Megee, C. E. Cormany.

Crops Course for Dairy Short Course. Nineteen students.
C. R. Megee.

Short Course—Potato Production. Thirty-five students.
C. E. Cormany.

Farm Crops 3, Summer Session 1923, Advanced Cereals, Grain Judging and Marketing. Eight students.
C. E. Cormany.

Farm Crops 4—Advanced Forage Crops. Ten students.
C. R. Megee.

Special Superintendent's Course. Twelve Weeks. Twelve students.
J. F. Cox, C. R. Megee, C. E. Cormany.

It is with pleasure that I report a spirit of friendly co-operation existing within the department which has, I am certain, been an important factor in the progress made during the season's work.

Yours very truly,
J. F. FOX,
Professor of Farm Crops.

REPORT OF THE DEPARTMENT OF FARM MECHANICS

To the President:—

Sir:—I have the honor to transmit the report of the Department of Farm Mechanics for the year 1922-1923.

The personnel of the Department has remained the same with the exception of the addition of Mr. H. J. Gallagher to the regular staff and instruction and the release of Mr. Dan Shafer with the transfer of the Blacksmithing and horseshoeing to the Farm and Horse Department.

The enrollment in the various courses under the plan of specialization in work in the Department has been somewhat less than when the courses were purely elective. It is felt that the loss of the introductory Wood and Forge Shop formerly offered by this department is partly responsible for the smaller enrollment.

The attendance in the Tractor courses has fallen off in the last year, part of which is probably due to the fact that the tractor has been better known and less of a novelty than when first used.

It is felt too that as the situation changes on the farm and it is possible to consider improvements in machinery and equipment that considerably more interest will be shown in Farm Mechanics work. Great interest has been shown in the last year in plans for buildings and conveniences. A desire for improvements in the home conveniences and sanitary conditions is also evidenced by increased correspondence along this line.

Perhaps no one thing is more keenly felt by members of the staff than need for space where work of the department can be grouped together. A great deal of equipment could be easily secured for instructional purposes if space could be provided for its housing. Under present conditions it is impossible to organize work so that it can be done efficiently. It is hoped that plans submitted for housing the Farm Mechanics work can have earnest consideration at an early date.

I desire to thank the men on the staff for their co-operation through the year. The variety of tasks imposed upon them and the conditions under which these have had to be performed, at times made this spirit of co-operation all the more appreciated.

POWER AND FARM MACHINERY

The work in gas engines and tractors has been more satisfactory during the past year than at any other time, owing to the fact that this course has been extended from a three to a five credit basis. Additional time is permitted the student to cover the work more thoroughly.

Rural high school superintendents are finding that the knowledge of gas engines and tractors is essential, to meet the demand of the students interested along mechanical lines. This is evidenced by the large number of men electing this course during the summer session. For the success of the above purposes, we are greatly indebted to the Engineering division of the College for the use of their outlay of equipment and also to the engine, tractor, and implement manufacturers, who have so kindly loaned their product to the Farm Mechanical Department.

The courses offered in Power machinery to the regular short course students, were well attended as usual. However, the intensive courses offered in Tractors and Trucks during the winter months were not so largely attended as in the years immediately following the war.

During the spring term as usual a course was offered in Farm Machinery to the regular students. A good enrollment was obtained. A special emphasis was placed on the study of machinery and on new machinery.

As a result of wide spread interest in radio reception this department offered a course in radio to the short course students of the college. This course enables the student to construct at the college, a radio set capable of long distance reception. Many took advantage of this offer.

FARM BUILDINGS AND CONVENIENCES.

Eight students elected the five credit senior option in farm building design given by Assistant Prof. Fogle in the winter term. Since this course has been lengthened it is not only possible for the student to give more time to original design but to take numerous trips with the class to study floorplans, various types of framing and to observe exterior design in both good and bad form.

Work in farm buildings was given to eleven men in the sixteen weeks short course by Instructor Gallagher. Mr. Gallagher has had considerable experience both in designing and remodeling farm buildings, and now lives on and operates a farm which makes his work particularly effective with the short course students.

Eighteen students enrolled in the course in Farm Conveniences offered for the regulars, twenty men enrolled in this course as offered in the sixteen weeks short course and eight in the special farm engineering course. The practical side of the subject is emphasized, the lectures and laboratory work being supplemented by trips to study practical installations and to see the septic tank under working conditions. The two former courses were given by Assistant Prof. Fogle and the latter by Instructor Gallagher.

EXTENSION.

Work in Drainage and Conveniences and Land Clearing will be found under separate heads. Considerable time has been spent this year in connection with experiment station work on Potato storage in working and ventilating systems for potato warehouses. As in other years many plans of all kinds have been sent out and assistance given in working out special and individual problems which cannot easily be reported, but which contribute to our fund of experience and in a demonstrational way to the betterment of farm equipment.

Yours very truly,
H. H. MUSSELMAN,
Professor of Farm Mechanics.

REPORT OF THE DEPARTMENT OF FORESTRY

To the President:—

Sir:—I have the honor to submit the following report for the Department of Forestry for the year ending June 30, 1923:

There were two changes in the teaching staff of the Department during the year. Mr. John C. DeCamp was appointed Assistant Professor of Forestry to take the place of Mr. P. L. Buttrick, who resigned on August 31 in order to travel and study abroad. Mr. DeCamp graduated from the College in the class of 1910 and has brought to the Department a wide knowledge of forest utilization and of lumbering acquired from many years' experience in the West and elsewhere.

Mr. Paul A. Herbert was appointed Instructor in Forestry to take the place of Mr. G. A. Garratt, who resigned on August 31 in order to continue his studies in the East. Mr. Herbert is a graduate of Cornell where he also took post-graduate work. He has accomplished some notable work in the study of forest insurance and is continuing such work here in addition to teaching.

The forestry summer school was held on the lands of the Antrim Iron Company near Mancelona. The company furnished us with the use of buildings for sleeping quarters, mess hall, kitchen and classroom and also furnished much of the equipment needed to operate the camp. I wish to take this opportunity of expressing our appreciation of their assistance in making the camp a success. In connection with the summer camp a large amount of data has been collected on the growth and management of hardwood forests in the northern part of the State, and the camp has brought the College into touch with many different communities. I feel that it has accomplished a great deal in interesting people both in forestry and in the College.

The forest nursery was operated as usual although the work was greatly handicapped by the late spring followed by unusually dry weather, making it difficult to handle the trees satisfactorily. Planting stock to the amount of 156,000 trees was shipped during the year, a considerable increase over the past few years. We are now beginning to feel the results of the small amount of seed sown in the nursery during the years of the war and next year we will have only a limited number of trees available for shipment. The interest in forest planting is steadily increasing and it is probable that the demand for trees during the next few years will exceed our suply. We have accordingly planted a large amount of seed this year. The maple sugar bush was operated as usual and some thinnings were made in the various plantations.

The Department has been represented at a number of meetings throughout the State and has taken an active part in the shaping of a forest policy for the State. There is a growing need for an extension specialist in forestry and I hope it will soon again be possible to fill this position.

The Department is at the present time hampered for lack of sufficient laboratory space. We have very excellent laboratory equipment, much of which cannot be used to the best advantage for lack of room.

In concluding I wish to express my appreciation of your interest and suggestions during the year.

Respectfully submitted,
A. K. CHITTENDEN,
Professor of Forestry.

REPORT OF THE DEPARTMENT OF HORTICULTURE

To the President:—

Sir:—I beg to submit the following report regarding the instructional activities of the Department of Horticulture for the year ending June 30, 1923.

There has been some reorganization of the work of the Department during the year, mainly in the direction of increasing the staff and making possible a greater specialization on the part of the staff members. In the first place Landscape Gardening was separated from the Department of Horticulture and placed in a Department by itself. The remaining field has been subdivided and allotted to different staff members as follows:

V. R. Gardner—Administrative work and general pomology (new appointee).
R. E. Marshall—Fruit handling and marketing.
F. C. Bradford—General pomology (new appointee).
G. E. Starr—Vegetable breeding and seed improvement (new appointee).
W. C. Dutton—Spraying.
N. L. Partridge—Viticulture.
R. E. Loree—Small fruit culture.
T. Gunson—Floriculture.

E. P. Lewis—Vegetable culture (new appointee).
H. M. Wells—Spraying (new appointee).

This reorganization has made possible not only a better preparation of material for the classroom and laboratory but the handling of students in smaller groups and a more efficient type of instruction incident thereto. It is also making possible a more efficient service to the various horticultural interests of the state. Throughout the year there has been a consistent effort to stiffen the courses. The results that are being obtained justify further effort in this direction.

Special effort has been made to encourage and develop graduate work in Horticulture. During the past year six men have been registered for graduate work in the Department and present indications are that this number will be materially increased during the coming session.

The present physical equipment and facilities of the Department are inadequate for the type of work that should be given both undergraduate and graduate students and for its investigational activities. However, the appropriation made by the last legislature for a new horticultural building together with its equipment and greenhouses should soon remedy this handicap. Need for equipment and personnel to develop further the floricultural work is particularly urgent. The situation is in the process of being remedied.

Considerable time has been spent in reorganizing the curricula for another year, in accordance with similar changes being made throughout the institution. It is believed that the changes in courses which will become effective next year will greatly strengthen the work in horticulture.

Particularly gratifying has been the interest in and support of the work of the Department by the Michigan State Horticultural Society, the Michigan State Florists and State Canners Associations and of other horticultural interests of the state. It is also a pleasure to be able to report the best of team work on the part of the various members of the Department.

Respectfully submitted,
V. R. GARDNER,
Professor of Horticulture.

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY

To the president:—

Sir:—I have the honor to submit the following report of the Department of Poultry Husbandry for the year ending June 30, 1923.

The poultry department holds an important and unique position in the varied types of service expected and rendered.

The chief function of the department, that of instruction, has been carried out as prescribed in the catalog. Additional effort has been made by all members of the staff to increase the efficiency and effectiveness of this work. A total of 369 students including regular, federal and short course have received instruction.

The second type of work that has been given special attention is the production and distribution of pedigree stock and eggs. The department is unable to produce sufficient stock to meet this growing demand. Over 500 breeding males and 1,000 settings of hatching eggs were distributed.

The greatest need of the department at the present time is for additional pedigree houses. The practice of mass mating such as we are forced to conduct, handicaps our work in breeding for increased production, size, color, hatchability of egg, resistance to diseases and numerous other problems of vital importance to the industry.

The poultry department of M. A. C. is the only laboratory in the state where such important problems of breeding can be carried on, and these problems, which are of economic importance, should be given serious consideration.

Mr. C. M. Ferguson and R. D. Ure of the Extension Division have devoted their time to lecture and demonstrational work, emphasizing all factors involved in economic production. Demonstration farms are now in operation in practically all counties under the direct supervision of the poultry extension division. These farms will be used as auxiliary breeding stations to demonstrate flock improvement by selective breeding.

I desire at this time to commend to you the splendid co-operative spirit and enthusiasm of the various members of the staff. We appreciate the interest you have taken in our efforts to build up a department respected by both students and farmers of the state.

Respectfully submitted.
E. C. FOREMAN,
Professor of Poultry Husbandry.

REPORT OF THE DEPARTMENT OF SOILS.

To the president:—

Sir:—It is with pleasure that I submit to you a report of the progress of the Soils Department. From an educational standpoint the year has been highly satisfactory. The students have manifested much interest in the courses offered and the quality of the work done by them has been much appreciated by the members of the teaching staff.

There is a rapidly growing interest in soils problems throughout the State. A large and increasing number of soil samples are received for examination and in addition many inquiries regarding the use of lime and fertilizer and for other information relative to methods of increasing the productivity of the soil.

One of the most perplexing problems of the Department is how to meet the requests from county agents, farmers clubs and others for talks on soil management. The members of the staff have met all such requests they could without neglect of their other duties. It appears that here is an opportunity to render a great service to the farmers of the State which is not being improved.

The work of the soil survey is progressing satisfactorily and is of much value to the members of the Department in aswering questions submitted by farmers and prospective farmers of the State. There are also quite a number of requests for soil maps. The soil acidity maps of various counties which are an outgrowth of the soil survey, have met with much favor. The field work of the survey is being supported by laboratory investigations.

In conclusion I wish to assure you of the support of every member of the Department in your efforts to enlarge and strengthen the college.

Respectfully,
M. M. McCOOL,
Professor of Soils.

REPORT OF THE DEPARTMENT OF SPECIAL COURSES.

To the President:—

Sir:—I herewith submit the report of the work of the Department of Short Courses for the year ending June 30, 1923.

The fifteen different Short Courses in agriculture offered by this department have been attended by 228 students. A detailed record of the various courses is given in the following list.

First year sixteen weeks' course	50
Second year sixteen weeks' course	19
First year eight weeks' course	23
Second year eight weeks' course	9
Dairy Manufactures' Course	12
Dairy Production course	28
Poultry course	18
Farm Engineering course	9
Horticultural course	25
Special course	4
Truck and Tractor course—First	7
Truck and Tractor course—Second	5
Truck and Tractor course—Third	4
Truck and Tractor course—Fourth	8
Ice Cream Making course	7
	228

Mr. Ashley M. Berridge, Associate Director of Short Courses, took entire charge of the work during the period between October 30, and

March. The successful management of these courses and of the short course men was due to the untiring efforts of Mr. Berridge.

Besides the regular instructional class work, weekly literary meetings featured by speeches and motion pictures, were held, athletics were encouraged, and a Choral Club and an orchestra were organized with the short course men. Mr. E. C. Sauve directed the Choral Club. Miss Delia H. Bemis directed the Short Course Orchestra. Mr. Larry Kurtz had charge of the basket ball team. The foregoing arrangements were planned in order to properly provide for the social and physical needs as well as the strictly educational requirements of the students.

The annual livestock judging contest was another feature of the past year. Mr. Donald Shepard, a first year sixteen weeks' man, was the individual high point winner, and received the cup offered annually by Dean R. S. Shaw. The winning team consisted of Lafayette Phillips, John J. Goodwins, and Russell Welchli, all 2nd yr. 8 wks. men.

Farmers' Week, a feature of our Short Courses, was under the direction of Assoc. Director A. M. Berridge, and was a marked success from all angles. The programs, exhibits, parade and shows were all well conducted. The estimated attendance during this week was about 5,000 farmers and farmers' wives. The administration, faculty, and student body co-operated to make this event an institutional rather than a divisional affair.

The Class Day Program held on February 28, was the closing feature of the years Short Course work. President Friday, Dean R. S. Shaw, and Prof. G. A. Brown gave the main addresses. Results of the livestock judging contest were announced and prizes awarded at this meeting.

The annual trip to the International Livestock and Hay and Grain Exposition was taken by forty Short Course men. While in Chicago the men also visited the large packing companies, the Grain Exchange and other large and notable enterprises. This feature of the short course work was well worth while.

Most of the Short Course instructional work was handled by the regular instructors and professors of the various departments. The following men, however, were paid all or in part from Short Course Funds:

E. B. Hill, Director.
Ashley M. Berridge, Associate Director.
H. J. Gallagher, Instructor in Farm Mechanics.
B. A. Powell, Instructor Creamery Mech.
George A. Getman, Instructor Gas Engines.
Dean Kelly, Instructor Farm Law.
J. S. Hyde, Instructor Soils.

Respectfully submitted,
E. B. HILL,
Director.

REPORT OF THE DEAN OF ENGINEERING

To the President:—

Sir:—I have the honor to submit my sixteenth annual report as Dean Engineering.

PERSONNEL OF DIVISION OF ENGINEERING.

Dean's Office.

G. W. Bissell, Dean.
Agnes McCann, Secretary.

Civil Engineering.

H. K. Vedder, Professor.
C. L. Allen, Associate Professor.
C. M. Cade, W. W. Hitchcock, B. K. Philp, and R. G. Saxton, Assistant Professors.
F. A. Gould, Instructor.

Drawing and Design.

R. K. Steward, Professor.
L. N. Field, C. Newman, and A. G. Sheele, Associate Professors.
C. L. Brattin, Miss C. Holt, J. W. Steward, and E. H. Stewart, Assistant Professors.
Miss E. Butler, O. W. Fairbanks, and J. Rising, Instructors.

Electrical Engineering.

A. R. Sawyer, Professor.
M. M. Cory, and L. S. Foltz, Associate Professors.
E. E. Kinney, Instructor.
R. L. Rayner, Graduate Assistant.

Mechanical Engineering.

H. B. Dirks, Professor.
G. W. Hobbs, W. E. Reuling and G. C. Wright, Assistant Professors.
J. A. Eicher, A. P. Krentel, D. T. Millard, G. J. Posthumus, C. N. Rix, B. Sangster, W. L. Watt, and C. R. Wiggins, Instructors.
E. C. Crawford, Assistant.

ENROLLMENT.

OFFICIAL FIGURES FOR 1922-1923.

	Regular	Eng. Ad.	Totals
Graduates	3		3
Seniors	92		92
Juniors	46	51	97
Sophomores	77	61	138
Freshmen			203
Specials			3
Total			536

GRADUATES.

Of the 92 seniors enrolled, 83 were graduated. The total of the graduates of the engineering course to date is 1,131, distributed by classes as follows:

1888	3	1897	7	1906	42	1915	55
1889	6	1898	4	1907	45	1916	66
1890	9	1899	7	1908	45	1917	63
1891	6	1900	10	1909	49	1918	34
1892	6	1901	11	1910	41	1919	20
1893	8	1902	20	1911	52	1920	44
1894	7	1903	27	1912	52	1921	68
1895	6	1904	19	1913	50	1922	70
1896	6	1905	27	1914	63	1923	83
Total							1131

Approximately 3,500 students have enrolled in the engineering course since its establishment in 1885.

COURSES OF STUDY.

The *engineering administration* course established last year was available for Juniors in the fall term of the current year with 60 per cent of the Juniors enrolled, and for Sophomores in the spring term with 45 per cent enrolled.

The course may be said to be successfully launched.

In accord with the general faculty plan for reduction in credit hours, all engineering courses have been remodeled, with 15 credit hours per term for the first two years and 17 credit hours per term for the last two years. The new courses will be presented and described in the college catalog.

ENGINEERING RESEARCH.

A formal recognition of research activity which will serve as a reason for an "engineering experiment station" at M. A. C., has been made by the appointment of a half-time graduate assistant in electrical engineering, radio-communication.

The legislative appropriation for research will permit and encourage further effort. It is proposed to utilize $3,000 to $5,000 during the coming year.

Under the direction of Professor Dirks of the mechanical engineering department, some interesting experiments have been conducted with the *Hvid* gas engine, the results of which will probably be published in bulletin form.

The alloy steels are being studied by the departments of chemistry and mechanical engineering, particularly as to the defects in casehardening processes and remedies therefor.

I recommend substantial encouragement for experimental work by the personnel of the division who have aptitude therefor.

Respectfully submitted,
G. W. BISSELL,
Dean of Engineering.

REPORT OF THE DEPARTMENT OF CIVIL ENGINEERING

To the President:—

Sir:—During the past year the work in the department has been carried on with a total of seven instructors which has necessitated in many cases the organization of recitation and practicum sections of such a size that the intimate personal contact between each student and the instructor was quite largely eliminated. However, the co-operation of most of the students has been such as to minimize the harmful effects of such a condition.

The department teaching staff for the year included the names listed below in order of rank.

H. K. Vedder, C. E.—Professor of Civil Engineering.
C. L. Allen, S. B. C. E. M. S.—Associate Professor of Engineering.
R. G. Saxton, B. S. M. S.—Assistant Professor of Civil Engineering.
C. M. Cade, B. S. C. E.—Assistant Professor of Civil Engineering
B. K. Philp, C. E.—Assistant Professor of Civil Engineering.
W. W. Hitchcock, B. S. C. E.—Assistant Professor of Civil Engineering.
F. A. Gould, B. S. C. E.—Instructor in Civil Engineering.

The following text books have been used in our classes during the year.

Breed & Hosmer's Surveying, Vol. 1.
Breed & Hosmer's Surveying, Vol. 2.
Seeley's & Ensign's Engineering Mechanics.
Boyd's Strength of Materials.
Malcolm's Graphic Status.
Hughes & Safford's Hydraulics.
Searles & Ive's Railroad Engineering.
Merriman & Jacoby's Roofs & Bridges, Vol. 1.
Merriman & Jacoby's Roofs & Bridges, Vol. 3.
Hool & Johnson's Concrete Engineers Handbook.
Blanchard's American Highway Engineers Handbook.

Harger & Barney's Highway Engineers Handbook.
Tucker's Contracts in Engineering.
Hosmer's Astronomy.
Turneaure & Russell's Public Water Supplies.
Elliot's Engineering for Land Drainage.
Metcalf & Eddy's American Sewerage Practice, Vol 1.

The tabulation which follows will answer all questions with reference to teaching schedule, the number of classes and the attendance therein.

Respectfully submitted,
H. K. VEDDER,
Professor of Civil Engineering.

CLASS WORK CIVIL ENGINEERING DEPARTMENT FOR COLLEGE YEAR 1922–1923.

FALL TERM.

Class	Subject	Number of Course	Instructor	Number hours per week	Number students in class
Sophomores	Surveying (Class)	C. E. 1a	Prof. Philp	2	17
Sophomores	Surveying (Class)	C. E. 1a	Mr. Gould	2	18
Sophomores	Surveying (Class)	C. E. 1a	Mr. Gould	2	11
Sophomores	Surveying (Class)	C. E. 1a	Mr. Gould	2	12
Sophomores	Surveying (Class)	C. E. 1a	Mr. Gould	2	19
Sophomores	Surveying (Class)	C. E. 1a	Prof. Cade	2	27
Sophomores	Surveying (Field)	C. E. 1a	Mr. Gould	2	15
Sophomores	Surveying (Field)	C. E. 1a	Mr. Gould	2	16
Sophomores	Surveying (Field)	C. E. 1a	Mr. Gould	2	25
Sophomores	Surveying (Field)	C. E. 1a	Mr. Gould	2	19
Sophomores	Surveying (Field)	C. E. 1a	Prof. Hitchcock	2	22
Sophomores	Surveying (Field)	C. E. 1a	Prof. Hitchcock	2	7
Sophomores	Surveying (Class)	C. E. 1b	Mr. Gould	2	16
Sophomores	Surveying (Class)	C. E. 1b	Prof. Hitchcock	2	24
Sophomores	Surveying (Field)	C. E. 1b	Prof. Saxton	4	12
Sophomores	Surveying (Field)	C. E. 1b	Prof. Hitchcock	4	12
Sophomores	Surveying (Field)	C. E. 1b	Prof. Hitchcock	4	17
Juniors	Mechanics	C. E. 4a	Prof. Philp	5	14
Juniors	Mechanics	C. E. 4a	Prof. Philp	5	13
Juniors	Mechanics	C. E. 4a	Prof. Allen	5	16
Juniors	Mechanics	C. E. 4a	Prof. Allen	5	13
Juniors	Mechanics	C. E. 4a	Prof. Cade	5	15
Juniors	Mechanics	C. E. 4a	Prof. Vedder	5	14
Juniors	Adv. Surveying (Class)	C. E. 6a	Prof. Cade	2	32
Juniors	Adv. Surveying (Field)	C. E. 6a	Prof. Cade	4	32
Juniors	Drainage (Class)	C. E. 18	Prof. Hitchcock	2	18
Juniors	Drainage (Class)	C. E. 18	Prof. Vedder	2	17
Juniors	Drainage (Field)	C. E. 18	Prof. Hitchcock	2	15
Junior	Drainage (Field)	C. E. 18	Prof. Hitchcock	2	17
Seniors	Surveying Methods (Class)	C. E. 2	Prof. Philp	3	23
Seniors	Surveying Methods (Field)	C. E. 2	Prof. Philp	4	23
Seniors	Graphic Status (Class)	C. E. 4d	Prof. Allen	2	25
Seniors	Graphic Status (Class)	C. E. 4d	Prof. Allen	4	25
Seniors	Hydraulics	C. E. 5	Prof. Cade	5	24
Seniors	Hydraulics	C. E. 5	Prof. Saxton	5	21
Seniors	Hydraulics	C. E. 5	Prof. Saxton	5	20
Seniors	Hydraulic Laboratory	C. E. 5a	Prof. Saxton	4	9
Seniors	Hydraulic Laboratory	C. E. 5a	Prof. Saxton	4	14
Seniors	Geodesy (Class)	C. E. 6b	Prof. Vedder	1	9
Seniors	Geodesy (Field)	C. E. 6b	Prof. Cade	4	9
Seniors	Bridge Stresses	C. E. 8a	Prof. Vedder	3	13
Seniors	Bridge Stresses	C. E. 8a	Prof. Vedder	3	9

CLASS WORK—CIVIL ENGINEERING DEPARTMENT FOR COLLEGE YEAR 1922–1923.

WINTER TERM

Class	Subject	Number of course	Instructor	Number hours per week	Number students in class
Sophomores	Sand, Cement & Concrete (Class)	C. E. 16a	Prof. Allen	2	23
Sophomores	Sand, Cement & Concrete (Class)	C. E. 16a	Prof. Hitchcock	2	15
Sophomores	Sand, Cement & Concrete (Lab.)	C. E. 16a	Prof. Allen	4	14
Sophomores	Sand, Cement & Concrete (Lab.)	C. E. 16a	Prof. Allen	4	12
Sophomores	Sand, Cement & Concrete (Lab.)	C. E. 16a	Prof. Hitchcock	4	12
Sophomores	Sand, Cement & Concrete (Lab.)	C. E. 16a	Prof. Hitchcock	4	7
Sophomores	Sand, Cement & Concrete (Lab.)	C. E. 16a	Prof. Hitchcock	4	7
Juniors and Seniors	Agricultural Engineering	C. E. 3a	Prof. Cade	3	22
Juniors	Mechanics	C. E. 4b	Prof. Saxton	5	13
Juniors	Mechanics	C. E. 4b	Prof. Cade	5	16
Juniors	Mechanics	C. E. 4b	Prof. Philp	5	14
Juniors	Mechanics	C. E. 4b	Prof. Philp	5	14
Juniors	Mechanics	C. E. 4b	Mr. Gould	5	13
Juniors	Mechanics	C. E. 4b	Mr. Gould	5	14
Juniors	Sewerage (Class)	C. E. 19	Prof. Cade	3	11
Juniors	Sewerage (Class)	C. E. 19	Mr. Gould	3	13
Juniors	Topographic Mapping (Lab.)	C. E. 7a	Prof. Vedder	6	12
Juniors	Topographic Mapping (Lab.)	C. E. 7a	Prof. Cade	6	8
Juniors	Topographic Mapping (Lab.)	C. E. 7a	Mr. Gould	6	8
Juniors	Topographic Mapping (Lab.)	C. E. 7a	Prof. Philp	6	17
Seniors	Bridge Analysis & Design (Lab.)	C. E. 8b	Prof. Vedder	8	22
Seniors	Masonry & Arches (Cl)	C. E. 9a	Prof. Allen	2	11
Seniors	Masonry & Arches (Cl)	C. E. 9a	Prof. Allen	2	10
Seniors	Masonry & Arches (Lab.)	C. E. 9a	Prof. Allen	4	11
Seniors	Masonry & Arches (Lab.)	C. E. 9a	Prof. Hitchcock	4	10
Seniors	Pavements	C. E. 10	Prof. Saxton	2	22
Seniors	Water Supply	C. E. 15a	Prof. Saxton	5	10
Seniors	State Highway Construction	C. E. 20a	Prof. Saxton	3	17
Seniors	Highway Law	C. E. 20b.	Prof. Saxton	2	17

CLASS WORK—CIVIL ENGINEERING DEPARTMENT FOR COLLEGE YEARS 1922–1923

SPRING TERM

Class	Subject	Number of course	Instructor	Number hours per week	Number students in class
Sophomores	Surveying & Leveling (Class)	C. E. 1c	Prof. Allen	3	28
Sophomores	Surveying & Leveling (Class)	C. E. 1c	Prof. Cade	3	19
Sophomores	Surveying & Leveling (Class)	C. E. 1c	Prof. Hitchcock	3	30
Sophomores	Surveying & Leveling (Class)	C. E. 1c	Mr. Gould	3	11
Sophomores	Surveying & Leveling (Field)	C. E. 1c	Prof. Saxton	4	20
Sophomores	Surveying & Leveling (Field)	C. E. 1c	Prof. Hitchcock	4	20
Sophomores	Surveying & Leveling (Field)	C. E. 1c	Prof. Hitchcock	4	28
Sophomores	Surveying & Leveling (Field)	C. E. 1c	Mr. Gould	4	11
Sophomores	Surveying & Leveling (Field)	C. E. 1c	Mr. Gould	4	10
Sophomores	Adv. Surveying (Class)	C. E. 6	Prof. Philp	3	18
Sophomores	Adv. Surveying (Class)	C. E. 6	Mr. Gould	3	12
Sophomores	Adv. Surveying (Field)	C. E. 6	Prof. Cade	4	12
Sophomores	Adv. Surveying (Field)	C. E. 6	Prof. Philp	4	18
Juniors	Strength of Materials	C. E. 4c	Prof. Allen	5	14
Juniors	Strength of Materials	C. E. 4c	Prof. Philp	5	17
Juniors	Strength of Materials	C. E. 4c	Prof. Philp	5	15
Juniors	Strength of Materials	C. E. 4c	Prof. Philp	5	20
Juniors	Strength of Materials	C. E. 4c	Prof. Hitchcock	5	10
Juniors	Strength of Materials	C. E. 4c	Prof. Hitchcock	5	8
Juniors	Railroad Surveying (Class)	C. E. 7	Prof. Saxton	3	19
Juniors	Railroad Surveying (Class)	C. E. 7	Prof. Cade	3	14
Junior	Railroad Surveying (Field)	C. E. 7	Prof. Saxton	4	16
Juniors	Railroad Surveying (Field)	C. E. 7	Prof. Cade	4	15
Juniors	Astronomy (Class)	C. E. 14	Prof. Vedder	2	19
Juniors	Astronomy (Class)	C. E. 14	Prof. Vedder	2	16
Juniors	Astronomy (Field)	C. E. 14	Prof. Vedder	2	10
Juniors	Astronomy (Field)	C. E. 14	Prof. Vedder	2	8
Juniors	Astronomy (Field)	C. E. 14	Mr. Gould	2	9
Juniors	Astronomy (Field)	C. E. 14	Mr. Gould	2	8
Juniors	Reinforced Concrete (Class)	C. E. 16b	Prof. Allen	3	14
Juniors	Reinforced Concrete (Lab.)	C. E. 16b	Prof. Allen	3	14
Juniors	Surveying Methods (Class)	C. E. 2a	Prof. Cade	3	24
Juniors	Surveying Methods (Field)	C. E. 2a	Prof. Cade	4	24
Seniors	Thesis	C. E. 11	Prof. Vedder	20	21
Seniors	Thesis	C. E. 11	Prof. Allen	5	6
Seniors	Contracts & Specifications	C. E. 13	Prof. Vedder	3	41
Seniors	Contracts & Specifications	C. E. 13	Prof. Vedder	3	42
Seniors	Theory of Structures	C. E. 21	Prof. Allen	4	20
Seniors	Road Construction (Class)	C. E. 17	Prof. Saxton	2	15
Seniors	Road Construction (Field)	C. E. 17	Prof. Saxton	6	15

REPORT OF THE DEPARTMENT OF ELECTRICAL ENGINEERING

To the President:—

Sir:—Herewith please find the report of Electrical Engineering for the year ending June 30, 1923.

The extended use of electricity stimulates to further study with the view of making the use of electricity more universal. Several problems are presented, some of them being as follows: To reduce the cost of a kilowatt hour in the face of rising cost of fuel and labor. It would also help to reduce the cost of freight haulage of raw material, for manufacturing purposes.

It is now seriously proposed to extend huge bus bars across the United States in order to make use of every natural source of power whether it be water, or oil and coal deposits. This power is to be converted into electrical energy and made available at any point in any amount by suitable connections. When this is accomplished, or as fast as it is accomplished, it will change the economic situation generally. There are many technical as well as administrative problems in bringing this about.

The Engineering Division of this College is now preparing options by which a student may prepare to participate in this work—either along technical lines or those of an administrative nature which require technical training.

An increasing number of students are taking advantage of these opportunities, as shown by the size of the Senior class for the last few years.

Year	Seniors	No. Graduating
1912	7	6
1913	10	12
1914	14	13
1915	10	9
1916	12	12
1917	14	14
1918	6	6
1919	4	3
1920	11	11
1921	15	16
1922	18	14
1923	25	24

Various inquiries have been made to find out what employers of college graduates want. The characteristics and their relative importance is indicated below—as brought out in a paper by Mr. J. W. Roe printed in "Industrial Management". These results are typical of what other investigators have found.

Character	41%
Judgement	17.5%
Efficiency	14.5%
Understanding of Men	14%
Knowledge of Fundamentals	7%
Technique	6%

All of our men including some who were not able to graduate have abundant opportunity for fields of usefulness at remunerative work.

However, it is necessary for us to add to our facilities and make such changes as are necessitated by new methods and ideas. This last year we have had one graduate student who has spent some of his time maintaining a broadcasting station. There is evidence that much might be accomplished by the College maintaining a suitable station for dissemination of valuable information—interspersed with entertainment to make it go down.

We need another man in this department for next year if we are to provide the courses which the catalog calls for.

Yours very truly,
A. R. SAWYER,
Professor of Electrical Engineering.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING

To the President:—

Sir:—The following is a report of the work of the Mechanical Engineering Department for the year ending June 30, 1923.

The personnel of the department at the end of the year was as follows:

H. B. Dirks—Professor.
W. E. Reuling—Assistant Professor.
G. C. Wright—Assistant Professor.
G. W. Hobbs—Assistant Professor.
C. R. Wiggins—Instructor in Metallurgical Courses.
A. P. Krentel—Forman in Wood Shop.
G. J. Posthumus—Instructor in Wood Shop.
D. T. Millard—Instructor in Wood Shop.
W. L. Watt—Instructor in Machine Shop.
C. N. Rix—Instructor in Machine Shop.
J. A. Eicher—Instructor in Foundry.
B. Sangster—Instructor in Forge Shop.
E. C. Crawford—Laboratory Engineer.
Ray Pearson—Tool Room Attendant.

Mr. C. R. Wiggins took the place vacated by Mr. P. J. Baker, and has given the work in the metallurgical courses in a satisfactory manner. Mr. Wiggins is making especial efforts to advance the work of the Foundry and it is to be hoped that sufficient funds will soon be available to make a start at least on the program he has outlined. He has continued the co-operation with the concerns in Lansing on problems in the heat treatment of steel.

Mr. Wright has continued the development of the courses in Industrial Management and Factory Planning, and it was with regret that I received his resignation some time ago. As the health of both Mr. and Mrs. Wright during the past has not been as it should, they feel a change of climate to be necessary and are leaving for California.

As in the past, assistance was given the Farm Mechanics Department in several of the Truck and Tractor courses. A course in Wood shop work was also given for Federal students.

The courses given during the summer school, were somewhat better attended than in previous years, there having been six men registered in

Wood Shop courses, and twenty-three men in three courses in the Machine Shop. Many of these were Federal students.

The policy of the Department in making trips to Lansing Factories was continued and considerably expanded. Visits were made to Foundries, Forge Shops and Heat Treating Shops in connection with the work of the Sophomore year, and to the Automobile Factories and Power Plants, etc., in connection with the work of the Senior year. I wish to express my appreciation of the many courtesies extended to us on these trips.

There was no new equipment purchased by the Department during the year. However, the Reo Motor Car Company were kind enough to present us with a six cylinder automobile engine, and the Olds Motor Works loaned us a similar engine for our work in the senior optional automotive courses. The Novo Engine Company continued the loan of a pumping equipment for another year.

We have continued our experimental work with the Hvid type gas engine and feel that we have made some progress especially in the study of the action of the burning of the oil in the cylinder. We are still using this engine as the basis for much of our work in the shops. Patterns are made for it by the Freshmen, Castings by the Sophomores in the Foundry, the Machine work is done by the Juniors, and the design of special jigs and fixtures for machining operations by the Seniors. The latter also have planned an organization, and a factory to manufacture the engine as part of the work in Industrial Management and Factory Planning.

The choice of the Seniors in the optional courses was again equally divided between atuomotive and industrial engineering.

It is unfortunate that financial conditions are not such as to allow of the purchase of some much needed equipment. We have long been in need of an oil burning semi Diesel type engine, of which we have none in our laboratories, and which are much used in small lighting and power installations. We are also greatly handicapped in the work of the Materials Testing Laboratory, because of lack of equipment. This lack has always necessitated giving much of the experimental testing a considerable time before the students have had the underlying theory, with consequent loss of effective teaching. In the machine shop, although our equipment seems quite complete, we are in need of several additional machine tools, and I am hoping that it will be possible to obtain permission of the War Department, to sell two of the larger machines purchased through the Caldwell Act, and use the funds for obtaining smaller equipment more suitable and necessary for the type of work done in the shops.

I wish to express my appreciation of the work of the various members of the department, and also of the assistance and co-operation of the electrical and chemical departments.

Respectfully submitted,
H. B. DIRKS,
Professor of Mechanical Engineering.

TABLE 1.—CLASS WORK OF MECHANICAL ENGINEERING DEPARTMENT.

FALL TERM, 1922.

Class	Subject	No. of Course	Instructor	Hrs. per week	No. of students	Student hrs. per week.
Freshmen......	Elements of Engineering....	1........	Mr. Bissell.................	1	191	191
Freshmen......	Wood Shop.............	2d.......	Mr. Krentel, Mr. Posthumus..	4	92	368
Freshmen......	Forge shop............	3d.......	Mr. Sangster...............	4	86	344
Juniors........	Steam Engines............	7a.......	Mr. Dirks, Mr. Hobbs.......	3	52	156
Juniors........	Steam Engines............	7ab......	Mr. Dirks.................	5	10	50
Seniors........	Boilers & Stokers..........	7c.......	Mr. Dirks..................	3	10	30
Juniors........	Engineering Laboratory....	13a......	Mr. Reuling, Mr. Hobbs.....	4	41	164
Seniors........	Engineering Laboratory....	13d......	Mr. Reuling, Mr. Hobbs.....	8	26	208
Freshmen......	Wood Shop..............	31.......	Mr. Krental, Mr. Millard....	5	137	685
Sophomores....	Forge Shop..............	41.......	Mr. Sangster...............	4	52	208
Sophomores....	Foundry................	51.......	Mr. Eicher................	4	56	224
Freshmen.....	Machine Shop...........	61.......	Mr. Wright, Mr. Rix.........	5	71	355
Juniors........	Machine Shop...........	62.......	Mr. Wright, Mr. Watt.......	5	10	50
Juniors........	Machine Shop...........	63.......	Mr. Watt..................	5	23	115
Juniors........	Seminar.................	71a......	Mr. Dirks..................	2	4	8
Seniors........	Seminar.................	72a......	Mr. Dirks..................	2	23	46
Sophomores....	Heat Treatment..........	81.......	Mr. Wiggins................	6	38	228
Federal........	Wood Shop..............	....	Mr. Krental................	4	24	96
Total.....	....	....	....	....	946	3526

TABLE 2.—CLASS WORK OF MECHANICAL ENGINEERING DEPARTMENT.

WINTER TERM, 1922

Class	Subject	No. of Course	Instructor	Hrs. per week	No. of students	Student hrs. per week
Seniors........	Industrial Management....	5a.......	Mr. Wright.................	3	26	78
Seniors........	Ind. Management (Lab.)...	5c......	Mr. Wright, Mr. Watt	9	12	108
Juniors........	Gas Engines..............	7b.......	Mr. Hobbs.................	2	33	66
Juniors........	Metallurgy..............	11a......	Mr. Hobbs, Mr. Wiggins.....	2	32	64
Seniors........	Timber Physics...........	11b......	Mr. Reuling................	5	19	95
Juniors........	Engineering Laboratory....	13ab.....	Mr. Reuling................	8	10	80
Juniors........	Engineering Laboratory....	13b......	Mr. Reuling................	4	35	140
Seniors........	Internal Comb. Engines....	17c......	Mr. Hobbs.................	8	16	128
Seniors........	Power Station Design......	18b......	Mr. Dirks..................	7	6	42
Seniors........	Costs & Accounting........	18c......	Mr. Bissell................	2	83	166
Freshmen......	Wood Shop..............	31	Mr. Krentel, Mr. Posthumus..	5	61	305
Freshmen......	Wood Shop..............	32.......	Mr. Millard................	5	67	335
Sophomores....	Foundry	52......	Wr. Wiggins, Mr. Eicher ...	6	75	450
Freshmen......	Machine Shop...........	61.......	Mr. Wright, Mr. Rix.........	5	60	300
Juniors........	Machine Shop...........	63.......	Mr. Wright, Mr. Watt.......	5	11	55
Juniors........	Seminar.................	71b......	Mr. Dirks..................	2	7	14
Seniors........	Seminar.................	72b......	Mr. Dirks..................	2	22	44
Seniors........	Heat Treatment..........	82.......	Mr. Wiggins................	5	23	115
Total.....	....	....	....	....	598	2585

TABLE 3.—CLASS WORK OF MECHANICAL ENGINEERING DEPARTMENT.

SPRING TERM, 1923

Class	Subject	No. of courses	Instructor	Hrs. per week	No. of students	Student hrs. per week.
Freshmen	Wood Shop	2d	Mr. Krentel, Mr. Posthumus	4	56	224
Freshmen	Forge Shop	3d	Mr. Sangster	4	58	232
Seniors	Factory Design	5b	Mr. Wright	7	12	84
Juniors	Engineering Laboratory	13c	Mr. Reuling, Mr. Hobbs	4	80	320
Juniors	Thermodynamics	17a	Mr. Dirks	4	29	116
Seniors	Auto. Design	17d	Mr. Hobbs	7	12	84
Seniors	Heating and Ventilation	18a	Mr. Reuling	3	23	69
Seniors	Tech. Prob	19a	Mr. Dirks, Mr. Wright	10	24	240
Freshmen	Wood Shop	32	Mr. Krentel, Mr. Millard	5	91	455
Sophomore	Forge Shop	41	Mr. Sangster	4	18	72
Sophomores	Foundry	51	Mr. Eicher	4	17	68
Freshmen	Machine Shop	61	Mr. Wright, Mr. Rix	5	44	220
Juniors	Machine Shop	62a	Mr. Wright, Mr. Watt	4	12	48
Juniors	Seminar	71c	Mr. Dirks	2	5	10
Seniors	Seminar	72c	Mr. Dirks	2	22	44
Total					584	2286

REPORT OF THE DEPARTMENT OF DRAWING AND DESIGN.

To the President:—

Sir:—I herewith present to you my seventh annual report as Head of the Department of Drawing and Design for the year ending June 30, 1923.

The personnel of the Department for the College year is given below:

R. K. Steward, C. E.—Professor.
Chace Newman—Associate Professor.
L. N. Field, B. M. E.—Associate Professor.
A. G. Sheele, A. M.—Associate Professor.
Miss C. L. Holt—Assistant Professor
J. W. Steward, B. M. E.—Assistant Professor.
E. H. Stewart, B. S. in M. E.—Assistant Professor.
C. L. Brattin, B. M. E.—Assistant Professor.
J Rising, M. E.—Instructor.
O. W. Fairbanks, B. S.—Instructor.
Miss Edith Butler—Instructor.

The work of the department has run along smoothly for the past year with each instructor doing better work and profiting by his or her past experience. Most of the members of the staff have been connected with the College for a number of years, and have spent their vacations in profitable study along their particular lines.

The Department will be permitted to offer Major and Minor work for students in the Science Division beginning next year. It will also offer Minor work for students in the Home Economics Division. The above arrangement will make it possible for students to prepare themselves along any one of three lines, namely: a broad academic training, commercial art work, or a normal training which will prepare them to teach art in our public schools

Some minor changes have been made in the courses for Engineers, but there is no reduction in total time allowed for drawing and Machine Design.

The following is a teaching schedule of the Department:

Respectfully submitted,
R. K. STEWARD,
Professor of Drawing and Design.

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN.

FALL TERM, 1922

Class	Subject	No.	Instructor	Hours	No. of students
Freshmen	Mechanical Drawing	4ab-1	J. W. Steward	6	20
Freshmen	Mechanical Drawing	4ab-2	Mr. Brattin	6	19
Freshmen	Mechanical Drawing	4ab-3	Mr. Stewart	6	15
Freshmen	Mechanical Drawing	4ab-4	Mr. Field	6	20
Freshmen	Mechanical Drawing	4ab-5	Mr. Brattin	6	18
Freshmen	Mechanical Drawing	4ab-6	Mr. Rising	6	15
Freshmen	Mechanical Drawing	4ab-7	J. W. Steward	6	14
Freshmen	Mechanical Drawing	4ab-8	Mr. Fairbanks	6	14
Freshmen	Mechanical Drawing	4ab-9	Mr. Brattin	6	18
Freshmen	Mechanical Drawing	4ab-10	Mr. Rising	6	21
Freshmen	Mechanical Drawing	4ab-11	J. W. Steward	6	18
Freshmen	Mechanical Drawing	4ab-12	Mr. Fairbanks	6	19
Freshmen	Freehand Drawing	1b	Mr. Scheele, Miss Butler	10	19
Freshmen	Freehand Drawing Science	21a-1	Miss Holt	4	20
Freshmen	Freehand Drawing Science	21a-2	Miss Butler	4	29
Freshmen	Freehand Drawing Science	21a-3	Miss Holt	4	21
Freshmen	Freehand Drawing Science	21a-4	Miss Butler	4	18
Sophomores	Descriptive Geometry	5a-1	Mr. Field	6	15
Sophomores	Descriptive Geometry	5a-2	Mr. Stewart	6	13
Sophomores	Descriptive Geometry	5a-3	Mr. Stewart	6	18
Sophomores	Descriptive Geometry	5a-4	R. K. Steward	6	17
Sophomores	Descriptive Geometry	5a-5	Mr. Field	6	18
Sophomores	Descriptive Geometry	5a-6	Mr. Rising	6	20
Sophomores	Descriptive Geometry	5a-7	R. K. Steward	6	19
Sophomores	Descriptive Geometry	5a-8	Mr. Fairbanks	6	20
Sophomores	Freehand Drawing	21b	Mr. Scheele	10	9
Sophomores	Freehand Drawing	1m	Mr. Scheele	10	10
Juniors	House Architecture	9	R. K. Steward	6	2
Juniors	Shades and Shadows	7-2a	Mr. Newman	6	12
Juniors	Kinematics	6c-4a	Mr. Field	4	9
Juniors	Adv. Freehand Drawing	1p	Mr. Scheele	6	1
Juniors	Adv. Freehand Drawing	21e	Mr. Scheele	10	1
Seniors	History of Art	2b	Miss Holt	3	19
Seniors	Mechanical Drawing (Ags.)	3b	Mr. Newman,	6	5
Seniors	Freehand Drawing	1s	Mr. Scheele	4	5
Seniors	Freehand & Mech. Drawing	1c	Mr. Newman	10	6
Freshmen	Freehand Drawing Science	21a-3a	Miss Butler	4	15
		21h			0
Total					553

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN

WINTER TERM, 1923

Class	Subject	No.	Instructor	Hours	No. of students
Freshmen	Machine Design	16a-1	Mr. Fairbanks	8	11
Freshmen	Machine Design	16a-2	Mr. Field	8	13
Freshmen	Machine Design	16a-3	Mr. Rising	8	12
Freshmen	Machine Design	16a-4	Mr. Fairbanks	8	16
Freshmen	Machine Design	16a-5	Mr. Brattin	8	16
Freshmen	Machine Design	16a-6	J. W. Steward	8	16
Freshmen	Machine Design	16a-7	J. W. Steward	8	13
Freshmen	Machine Design	16a-8	Mr. Rising	8	11
Freshmen	Machine Design	16a-9	Mr. Newman	8	13
Freshmen	Machine Design	16a-10	Mr. Newman	8	18
Freshmen	Machine Design	16a-11	J. W. Steward	8	19
Freshmen	Machine Design	16a-12	Mr. Fairbanks	8	21
Freshmen	Freehand Drawing	1h	Mr. Scheele, Miss Butler	10	13
Freshmen	Freehand Drawing	21a-1	Miss Holt	4	12
Freshmen	Freehand Drawing	21a-2	Miss Butler	4	15
Sophomores	Descriptive Geometry	5b-1	Mr. Stewart	5	15
Sophomores	Descriptive Geometry	5b-2	R. K. Steward	5	15
Sophomores	Descriptive Geometry	5b-3	E. H. Steward	5	14
Sophomores	Descriptive Geometry	5b-4	Mr. Field	5	13
Sophomores	Descriptive Geometry	5b-5	R. K. Steward	5	17
Sophomores	Descriptive Geometry	5b-6	E. H. Stewart	5	18
Sophomores	Descriptive Geometry	5b-7	R. K. Steward, Mr. Rising	5	12
Sophomores	Descriptive Geometry	5b-8	E. H. Stewart	5	13
Sophomores	Freehand Drawing	1n	Mr. Scheele, Miss Butler	10	13
Sophomores	Freehand Drawing	21c	Mr. Scheele	10	10
Juniors	Machine Design	6d	Mr. Field	3	13
Juniors and Seniors	Freehand and Mech	2c	Mr. Newman	10	6
Juniors	Machine Design	6f	Mr. Brattin	6	16
Senior	Machine Design	6f	Mr. Field	6	24
Juniors	Freehand Drawing	1q	Mr. Scheele	10	1
Juniors	Freehand Drawing	21f	Mr. Scheele	10	1
Juniors	Freehand Drawing	1r	Mr. Scheele	10	1
Seniors	History of Art	2e	Miss Holt	3	23
Seniors	Adv. Drawing and Color	1t	Mr. Scheele	4	2
Total					446

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN

SPRING TERM, 1923

Class	Subject	No.	Instructor	Hours	No. of students
Freshmen	Machine Design	16b-1	J. W. Steward	8	8
Freshmen	Machine Design	16b-2	Mr. Rising	8	14
Freshmen	Machine Design	16b-3	Mr. Brattin	8	10
Freshmen	Machine Design	16b-4	Mr. Stewart	8	16
Freshmen	Machine Design	16b-5	Mr. Rising	8	10
Freshmen	Machine Design	16b-6	Mr. Newman	8	10
Freshmen	Machine Design	16b-7	Mr. Stewart	8	11
Freshmen	Machine Design	16b-8	Mr. Fairbanks	8	10
Freshmen	Machine Design	16b-9	Mr. Field	8	9
Freshmen	Machine Design	16b-10	Mr. Brattin	8	20
Freshmen	Machine Design	16b-11	J. W. Steward	8	21
Freshmen	Machine Design	16b-12	Mr. Fairbanks	8	18
Sophomores	Mechanical Drawing	3a-1	R. K. Steward	4	9
Sophomores	Mechanical Drawing	3a-2	R. K. Steward	4	12
Sophomores	Freehand Drawing	1w-1	Miss Holt	4	12
Sophomores	Freehand Drawing	1w-2	Miss Butler	4	14
Sophomores	Freehand Drawing	1w-3	Miss Holt	4	13
Sophomores	Freehand Drawing	1w-4	Miss Butler	4	11
Sophomores	Freehand Drawing	1w-5	Miss Holt	4	6
Sophomores	Freehand Drawing	1w-6	Miss Butler	4	20
Sophomores	Freehand Drawing	1w-7	Miss Butler	4	18
Sophomores	Freehand Drawing	1w-8	Miss Butler	4	10
Sophomores	Freehand Drawing Science	21d	Mr. Scheele	4	11
Juniors	Machine Design	6d-4a	Mr. Field	3	5
Juniors	Mechanical Drawing	3b	R. K. Steward	....	2
Juniors	Freehand Drawing	1r	Mr. Scheele	10	3
Juniors	Freehand Drawing Science	21g	Mr. Scheele	1	1
Juniors	Freehand Drawing	1q	Mr. Scheele	10	1
Seniors	Freehand and Mech. Drawing	3c	Mr. Newman	10	6
Seniors	Topographical Drawing	3d	Mr. Newman	....	1
Seniors	Adv. Freehand Drawing	1o	Mr. Scheele	10	9
Seniors	Adv. Freehand Drawing	1u	Mr. Scheele	10	0
Seniors	History of American Art	2d	Miss Holt	3	8
Seniors	Adv. Freehand	1s	Mr. Scheele	10	1
Seniors	Adv. Freehand	1t	Mr. Scheele	10	1
Total					355

REPORT OF THE DEAN OF HOME ECONOMICS

To the President:—

Sir:—I have the honor to present the following report of the Division of Home Economics for the fiscal year ending June 30, 1923.

PERSONNEL OF DIVISION.

Louise H. Campbell, Acting Dean.
Ethel G. Webb, Associate Professor.
Winnifred H. Gettemy, Associate Professor.
Anna Bayha, Associate Professor.
Lola G. Yerkes, Associate Professor.
Osee Hughes, Assistant Professor.
Marie Dye, Assistant Professor.
Louise H. Clemens, Assistant Professor.
Harriet Y. Colvin, Instructor.
Sylvia Borgman, Instructor.
Josephine Hoffarth, Instructor.
Ruth Wilson, Instructor.
Ruth Cowan, Instructor.
Irma Gross, Instructor.
Florence A. Keepman, Instructor.
Rachel Talbot, Instructor.
Mrs. Harry Persons, Instructor (Part Time).
Grace A. Cone, Instructor (Part Time).

Miss Irma Gross was granted leave of absence for the spring term, 1923, in order to pursue studies toward her Master's Degree at The University of Chicago, as well as to do some teaching while here.

Miss Josephine Hoffarth came to us January 1, 1923, to substitute for Miss Gross during the spring term. Miss Hoffarth also taught the General Foods Classes.

Miss Grace A. Cone, of the Lansing Social Service Bureau, had charge of our course in Social Service Work, (H. E. 13 a, b, c), during the fall and winter terms but, because of a lack of finances, this work had to be discontinued at the end of the winter term.

Mrs. Lora Person was employed to teach Home Care of the Child (H. E. 30) during the fall and winter terms but, because of the small number of students classifying in this subject, it was also discontinued at the end of the winter term.

Miss Ethel G. Webb, of Carnegie Institute, Pittsburgh, Pennsylvania, came to Michigan Agricultural College on January 1, 1923, as Associate Professor in Costume Design.

Mrs. Harriet Y. Colvin came to Michigan Agricultural College about

October 15, 1922, to take charge of the Flower Pot Tea Room and also to do some advanced Institutional teaching.

The following members of the Home Economics Staff have tendered their resignations, effective at the close of the spring term, 1923:

Mrs. F. W. Keepman (because of duties at home).

Miss Ruth Wilson (to be married in the Fall).

Miss Anna Bayha (Granted leave of absence for coming year, in order to make tour around world and spend six months at Columbia).

Miss Lola Yerkes (Merrill-Palmer School will pay all members of Faculty from M. P. funds).

STUDENT ENROLLMENT.

The total enrollment for the year 1922-23 was as follows:

Senior	65
Junior	69
Sophomore	87
Freshmen	115
Specials	5
Summer School	105
	446

COURSE OF STUDY.

The course of study adopted at the beginning of the school year, 1921-22, was used the past year and found to be very satisfactory in most respects. The course for 1923-24, however, has been revised from the twenty to a sixteen hour credit basis to conform with the general revision of the college course of study.

After numerous conferences with members of the various departments of Michigan Agricultural College, the course, as outlined below, has been adopted and will be used during the next school year. The teaching staff in other divisions have expressed themselves as being delighted with the possibilities it affords for a wider selection in subjects and feel that, as a result, a broader type of college work will be voluntarily taken.

Seven Majors are offered in the revised Home Economics Course: General, Foods and Nutrition, Institutional Management, Clothing, Textiles, Related Arts and Vocational. In each of these the work is practically the same for the first two years. The Majors are offered to permit the student to specialize in the phase of Home Economics in which she is most interested. In the junior and senior years, a minor in a related subject consisting of 8 to 16 hours per year is required. In some majors the minor is specified.

All majors prepare for teaching and a student in any one of them may obtain the state four year certificate to teach by electing Education 2, 1a, and either 3, 3a or Economics 2 or 7. It is strongly recommended that she take Practice Teaching, Education 3a. This certificate may be changed to a life certificate at the end of four years' successful teaching.

The General Major is designed to give students general training in Foods, Nutrition, Clothing, Textiles, Home Management and Child Care, and to allow at the same time a wide range of electives so that they may take four years in any of the sciences, in English, in Language, in History or in Economics, if they so desire. This type of training will prepare for teaching Home Economics in elementary and secondary schools, for social service workers and for teachers in related fields of science and letters, and for homemaking.

The foods and Nutrition Major gives the students advanced work in Foods, Nutrition and Institutional Management. The minor is elective. This will give preliminary preparation for the profession of dietitian, director of nutrition clinics, visiting housekeeper, hospital dietitian, demonstrator for commercial firms and special editor on magazines for women.

The institutional Management Major includes tea room management, cafeteria management, advanced cookery, accounting and marketing. The minor is economics. The student is qualified to be director of school lunch, cafeteria manager, tea room manager, etc.

The Clothing Major included advance work in clothing construction, tailoring, costume design, millinery, home decoration, and textile buying. The minor is elective. It gives preliminary training for buyers in department stores, designers of clothing and millinery, interior decorators and for editorial work on women's magazines.

The Textile Major is arranged to give training in all phases of textile chemistry, buying and selling of textiles, economics, clothing construction and home furnishing. The minor is chemistry. It gives specific preparation for commercial positions and leads to the following: buyers in stores, advertising, teaching of textiles and textile chemists.

The Related Arts Major includes courses in home furnishing, costume design, applied design, clothing and art. The minor is art. This gives preliminary training for commercial positions as advisors in clothing and house furnishing departments, for editors for women's sections in magazines and papers, and, with some further art training, to professional costume designing and interior decoration.

The Vocational Major fulfills the requirements for teaching under the Smith-Hughes laws. It requires work in clothing, foods, dietaries, child care, home management and education, including practice teaching. The student receives a recommendation of approval to teach in a Smith-Hughes school, in addition to the regular four year state certificate. The minor is education.

The course is strengthened inasmuch as Chemistry is put in the fall term, which makes it possible for students in the spring term to choose either Foods or Clothing in their Freshman year.

Another desirable feature about the revision of the course is the fact that those who are interested in Drawing and Design may begin in the fall term, Freshman year, by postponing Mathematics until fall term, Sophomore year.

PROBLEMS IN NUTRITION (H. E. 14 a, b, and c):

The Home Economics Division has materially broadened the scope of its work this year by the employment of Marie Dye, Ph. D. in Nutrition and Chemistry from the University of Chicago, who was brought here for the purpose of developing a graduate and research department in this Division. A fund of $1,600 was made available for the equipment of a small nutrition laboratory for use for research and for advanced nutrition courses. A few large pieces of apparatus which can be moved to the new Home Economics Building have been purchased this year such as a Benedict Portable Respiration apparatus, and an excellent electric oven, centrifuge and balance. Other supplies were bought in small amounts, enough to take care of classes for this year. This equipment will form the foundation for the laboratory provided in the new building.

Miss Dye's work this year has been one of securing, installing and organizing the equipment in the laboratory and the conducting of classes in advanced nutrition.

Two students have already made application for graduate work, looking toward receiving an advanced degree and plans have been made for starting research as soon as the laboratories in the new building are available.

SPECIAL INVESTIGATION IN NUTRITION (H. E. 15):

The content of this course has been entirely changed from that of last year. The lecture work has consisted of a study of special phases of Nutrition, such as the problem of the cause and prevention of rickets, the relation of iodine in the food supply to goiter, and the relation of calcium to the formation of bones and teeth.

The laboratory work has consisted of actual experiments with rats, demonstrating the effects of proper and improper selection of foods upon the growth and health of the animal. New stock animals have been procured for the colony and it has been materially enlarged. New cages have been built for the stock animals and small cages purchased for those on experimental diets.

The value of this course to the student is perhaps self evident since, as is easily seen, it brings home very forcibly to the student the relation between the selection of food and health.

RESEARCH PROBLEMS IN NUTRITION (H. E. 16):

The lecture work of this course has been devoted especially to the study of the research methods, used for the establishment of standards for total food requirements and protein requirements.

The laboratory work has been a continuation of the animal experiments started previously and the measurement of basal metabolism of all students in the class, together with the determination of nitrogen intake and output on high and low protein diets.

This course is preparatory for the beginning of research work as graduate students and gives the student an appreciation of the method and value of research.

PROBLEMS IN NUTRITION (12a, b and c.):

The field work in Nutrition (H. E. 12a, b and c) which was begun last year, as a separate course elective for all students but Food Majors and a required course for them, has been continued during the year

1922-23. We have again secured the co-operation of the Lansing Board of Health and of the school authorities of Lansing and of East Lansing, so that special classes for under-nourished children have been made a part of the regular curriculum. Classes were held in the upper grade rooms of the two fresh air schools, Townsend Street and East Park, and for special groups in the Cedar Street School in Lansing and the Central and Liberty Hyde Bailey Schools in East Lansing.

The method of conducting this work has differed in certain details from that of last year in that it has been intensive rather than extensive. The number of children reached has been less (about one hundred), but each child has received individual attention, including home visits by the college students. A serious effort has been made to obtain co-operation with the home, emphasis being placed on the development of good health habits rather than upon gains in weight alone, since we are of the opinion that a knowledge of the fundamental requirements for food, rest and exercise, is of more permanent benefit than gains in weight which may be temporary.

Our results do show gratifying gains in weight, as is brought out in the table quoted on the next page. Certain specific cases, of course, show gains far in excess of the average, such as Doris E. and Virginia G. at the Townsend Street School, who gained thirteen and fourteen pounds respectively, and three boys and one girl at other schools, who have gained ten pounds each in a period of seven months, the normal rate of gain being three and one-half pounds for this length of time.

TABLE.

Children enrolled at beginning of year		105
Children enrolled at end of year		82
Percentage of normal gain		
Cedar Street	107.0	
East Lansing	105.0	
Townsend	156.0	
East Park	157.0	
Average	131.0	

Other results, even more important, are not easily shown, since statistics for changes in food habits are practically impossible to obtain. The following are illustrative of such results, which occurred in a majority of cases

Milton J., son of a Greek restaurant keeper, at the beginning of the term ate irregularly and lived almost entirely on "weiners" and pie. About the middle of the term his mother reported that he was eating three meals a day, breakfast consisting of oatmeal, milk, bread and butter dinner of meat, potato and other vegetables, and supper of potato, egg, fruit and milk.

Ora G. was extremely fond of sugar and ate it in great excess, to the exclusion of other foods. His mother had great difficulty in keeping it away from him. At the end of the term, however, he had stopped this habit, and was developing good habits of food selection.

Many of the children have learned to like vegetables which they would not eat before. Others have learned to eat and to like milk and eggs.

There are many benefits to the college students enrolled for this work, among them being the development of a sociological interest, direct contact with the results of improper feeding, practical experience in the managing of children from the ages of 8 to 14 years and practice in conducting health classes. It also makes it possible for them to enter a vocation other than teaching home economics in the high school and two of our students this year have gone into health work; one in the state of Michigan and the other in the Southwest District of the American Red Cross.

CLOTHING (H. E. 50a and 90):

The content of these two courses has been almost identical this year, preparatory to making the Freshman sewing course uniform for all students next year.

In the Clothing courses the aim has been to present problems more from the standpoint of selection than construction. Selection is made from the economic, hygienic, artistic and technical viewpoint.

Lectures from the following local merchants have been of great value in teaching selection, especially from the economic point of view:

Mr. Sprowl, of Sprowl Brothers.
Mr. Metcalf of Shubel's Shoe Store.
Mr. Baker, of F. N. Arbaugh & Co.

Two representatives from Mill's Dry Goods Company gave demonstrations and talks and, through the courtesy of Mr. Crotty, who furnished the material, the Dennison Company Representative gave a demonstration of costumes and various articles made from their products.

In H. E. 50, which includes the study of children's clothing, an experiment was carried out by an Instructor who has been a designer of children's clothing, constructing one series of garments according to factory methods, followed by one made according to custom methods. It was found that conditions in the college work room did not duplicate factory conditions sufficiently to make it a problem to be continued.

In H. E. 52 the work in tailoring has been in charge of Mr. Jaques Joseph, a Lansing Tailor. This has proven much more satisfactory than the plan followed last year of sending the students down town for this training.

H. E. 54 has been limited to a special problem in dress design.

FIELD PROBLEMS IN TEXTILES (H. E. 55):

The purpose of this course is to permit the student to do advanced work along the line in which she is most interested. One student this year spent half of her time in one of the interior decorative studios in Lansing and the other furnishing the guest room of the Practice House with a limited amount of money.

Another student, who was a transfer from another College and who was interested in shop methods of dress construction, spent her laboratory hours in the Margaret Hoover Shop. Her lecture periods were spent in conference with the Instructor in charge.

INSTITUTIONAL MANAGEMENT (H. E. 20 and 21).

The growth and development of this work during the past year has been very satisfactory. The lunch room project at the East Lansing High School has been continued, and this experience has been invaluable to the students.

Institutional Management classes were conducted in the Womans' Commons and in the Flower Pot Tea Room. The course consisted of practice work in the kitchen of the Woman's Commons, complete preparation of meals, menu planning, study of equipment in various Institutions, and observation of lunch rooms, tea rooms, cafeterias and hotels. If the Institutional Management classes are carried on in the same manner next year, more definite arrangements should be made with the Director of the Womans' Commons.

WOMANS' COMMONS:

At the beginning of the spring term, 1923, all of the Home Economics students on the campus were required to take their meals at the Womans' Commons or at the College Residence. This was done because of the fact that so many of the students were eating at irregular hours and did not select the proper food. The Commons, this past year, has been operated the same as formerly; that is the Home Economics Division has assumed complete responsibility for all over-head expense and service.

At the end of the school year, the Commons paid to the College $1,200 for rent and all expenses incurred, including Miss Borgman's salary, with a balance of cash on hand amounting to $3,414.00, for replacing old equipment.

It is the opinion of the people in the Household Science Department that all food purchasing, as well as the general management, should be under one head. Under such an arrangement, all foods required by the various departments could be secured at wholesale rates.

FLOWER POT TEA ROOM:

The Flower Pot Tea Room was opened the latter part of January under the supervision of Mrs. Harriet Y. Colvin. The purpose of running this Tea Room was to give Advanced Institutional Management (H. E. 22) to the students desiring to take this work. The demand for this course is greatly increasing and, in order to vary the different types of problems, it was thought desirable to open the Tea Room, since it offered a type of training impossible to obtain in any other capacity. The training in the Tea Room includes serving, assisting in the preparation of food, managing the dining room at times, and the students were given the entire responsibility of taking care of Sunday night luncheons. This develops independence and self reliance, which the students have no opportunity to obtain in a larger Institution, such as the Womans' Commons. In addition, they have the problem of management to make a profit, which has not been any part of the training offered in the Womans' Commons.

Three students, taking this course, have gone into Institutional Management work this year and we have received word of several openings with exceptional futures for students qualified along this line.

Unfortunately, the Tea Room has not been a financial success. This has been partly due to the fact that it was not started until late in the season and was not established until winter had set in. The students, of course, had already made arrangements for their board and very few could afford to take their meals outside of the Dormitories.

The Home Economics Department feels very strongly that the Tea Room should be kept open, if possible, or at least until the Union Memorial Building is completed.

HOME MANAGEMENT PRACTICE (H. E. 32):

The work at the Practice House has been continued this year as formerly.

Field trips taken by Practice House students include the Lansing Steam Laundry, the Western Electric Company, Jury-Rowe Company, and Hoover & Bond, these trips being supplemented by special reports and investigations by members of the class.

The work of furnishing the Practice House has been continued this year, with the remainder of the fund subscribed by the Alumnae. The guest room has been completely furnished and several new pieces of furniture have been purchased for the down-stairs rooms. The senior girls, of their own volition, are purchasing a piano, by subscribing $15.00 a month until all payments are completed. .During the spring term, the floors of the Practice House were repainted and a new rug and furniture added to the Instructor's living room.

During the school year, there were forty-eight residents in the Practice House.

MERRILL-PALMER SCHOOL:

The work which the students are doing at Merrill-Palmer School in Detroit, is proving exceedingly valuable and the interest in this project is rapidly increasing among the students. There have been numerous requests from students on the Campus to be allowed to take the course at Merrill-Palmer, because they are beginning to appreciate the real worth of such a course.

The Merrill-Palmer Board has arranged to pay the salaries of their instructors, without outside assistance and, therefore, Miss Lola G. Yerkes is no longer on the pay-roll of Michigan Agricultural College. This has made no difference, however, in the number of M. A. C. girls who will attend Merrill-Palmer next year, since they will continue to take six of our girls each term, although the entire number of students will be limited to twenty. The Merrill-Palmer Board is highly pleased with the type of girls we are sending there.

Students returning from Merrill-Palmer express a very strong desire that more general Psychology be given at Michigan Agricultural College, in order to prepare them for the more advanced work at Merrill-Palmer.

HOME CARE OF THE CHILD (H. E. 34):

This course was given on child welfare including lectures and demonstrations by a trained woman on the care of well children and how to keep them well, both physically and mentally. When the new Home Economics Building is completed, it is hoped that this course can be given more attention and be so developed as to compare very favorably with the same type of work being offered at the Merrill-Palmer School in Detroit.

PLANNING OF THE NEW HOME ECONOMICS BUILDING.

A great deal of time and thought has been spent by the Home Economics Faculty in remodeling the plans for the new building. Inasmuch as a well equipped kitchen and dining room will be installed in the Union Memorial Building, it was deemed advisable to cancel the plans for a cafeteria in the Home Economics Building. The changes that were made have been passed upon and approved by the Building Committee of the State Board of Agriculture.

The equipment for the building has been carefully worked out by members of the Home Economics Faculty but, at the time of writing this report, no equipment has been ordered. This has been delayed, awaiting the appointment of a permanent Dean of Home Economics, so that she might have an opportunity to pass upon the equipment before it is installed.

CHANGES MADE IN DORMITORIES AND HOUSE MOTHERS:

At the beginning of the school year there were ten Dormitories—Womans' Building, Abbott Hall, Senior House, Virginia Halladay House, Johnson House, Waterbury House, Black House, College Residence, Corcoran House and the Kathryn Friday House, with the following House Mothers: Mrs. Baker, Mrs. Murdock, Miss Yakely, Mrs. Peterson, Mrs. Dow, Mrs. Black, Mrs. Eastman, Mrs. Corcoran and Mrs. Weamer.

In November, Mrs. Reason was appointed House Mother at the Womans' Building.

During the winter, the epidemic of Influenza and Scarlet Fever was so great that it was necessary to give up the Kathryn Friday House for hospital use. The girls were placed in the Black and Corcoran Houses. Later when the Lambda Chi Alpha House burned, the Kathryn Friday Dormitory was used at a "Frat" House until the close of the year.

Mrs. Murdock resigned at the close of the winter term, and Mrs. Weamer filled this vacancy as House Mother at the Senior House during the spring term.

It is recommended that great care be exercised in the selection of House Mothers for 1923-24. The House Mothers should be women of broad training, experienced with young people and of the type qualified to bring about the building of strong characters.

STUDENT SELF GOVERNMENT ASSOCIATION:

The Student Self Government has established itself as a permanent feature of life at M. A. C. Many points have been noted that need to be strengthened and when this is done a better system will be established, resulting in a clearer understanding and better co-öperation between officials of the League and the House Mothers. In this connection, it is felt that there should be a tightening of the rules relating to student privileges, especially in reference to Freshmen. This would result in great benefit to the college as well as being a permanent help to the girls.

In closing the work of the Home Economics Division for 1922-23, I wish to acknowledge the splendid co-operation and excellent service of the Home Economics Faculty. I also wish to acknowledge the help and interest received from other departments in further developing the work.

Respectfully submitted,
LOUISE H. CAMPBELL,
Acting Dean of Home Economics.

REPORT OF THE DEPARTMENT OF TEACHER TRAINING.

To the President:—

Sir:—Herewith please find report of the above department for the period ending June 30, 1923:

Personnel of the Department:

Walter H. French, Professor of Agricultural Education.
Dean Louise H. Campbell, Professor of Home Economics.
E. Lynn Grover, Associate Professor.
Branson A. Walpole, Assistant Professor.
Mrs. Josephine Hart Fogle, Assistant Professor.
Miss Emma P. Garrison, Assistant Professor.

The Department of Teacher Training has charge of presenting the courses in Education, and directing the practice teaching for those who are preparing to teach agriculture and home economics, also the visitation and inspection of schools where our graduates are employed.

The courses in Education for the teachers of agriculture are as follows:

Education 4,	Educational Psychology
Education 5,	General Methods and School Administration.
Education 6,	Special Methods in Teaching Agriculture.
Education 6a,	Practice Teaching.

The courses in Education for the teachers of home economics are as follows:

Education 1,	Psychology.
Education 1a,	Special Methods in Teaching Home Economics.

Education 2, General Methods and School Management.
Education 3, History of Education.
Education 3a, Practice Teaching.

During the year 186 agricultural students have pursued the courses in Education and of these 66 were enrolled in Education 6; 66 in Education 4; 54 in Education 5; and 55 graduates were granted teachers' licenses.

During the same time, 280 different students from the Home Economics Division have been enrolled in educational courses and of these 93 were in Education 1; 101 in Education 2; and 86 in Education 3; and from this Division 58 women were graduated and granted teachers' licenses. These figures show that the college is doing its fair share towards providing teachers of vocational subjects for the public schools of the state. So far, we have been able to provide sufficient number of teachers of agriculture and there has been a surplus each year which has been distributed in nearby states. Practically all of our graduates in home economics are absorbed by the home economics schools in Michigan. This institution at the present time is providing practically fifty per cent of the home economics teachers of the state.

This Department operates so far as teacher training is concerned, under the provisions of the Smith-Hughes Law and under the requirements made by the State Board for Vocational Education.

By arrangement between the Boards of Education of East Lansing and Haslett, classes are provided for practice teaching in agriculture and in home economics. A separate building is provided for the classes in agriculture and a four unit course, corresponding to the regular work in the public schools, is maintained.

The practice teaching is under the direct management of Mr. Grover and Mr. Walpole. We also use the consolidated school at Haslett for certain classes in agriculture.

In both East Lansing and Haslett there is a department of home economics organized on the regular Smith-Hughes plan. The equipment is provided by the college. Mrs. Fogle and Miss Emma P. Garrison have immediate charge of the practice teaching in home economics.

It is our plan to have the teacher trainers visit schools each year where our graduates are employed. We make it our business to inspect the work of the beginners—that is, those who are out on their first year of teaching, and render whatever service we can to enable them to organize their departments of agriculture and home economics according to the State Plan; also check up on their methods of work, both in school and in the community. This we call "teacher training in service." It gives us an opportunity to assist the young people and at the same time determine whether our teacher training work is effective.

The expense of the department for instruction for the year, has been approximately $19,000 including the summer school.

During the current year, there have been seventy-six agricultural departments in connection with the public schools of the state and these departments will share in the distribution of federal and state funds. There are 38 schools giving instruction in home economics for which federal and state aid is allowed.

It should be said that all the young men and women who complete their college course, together with courses in Education, do not enter upon the profession of teaching. Because of their training and experience, many of them occupy managerial positions and others are to be found as professional specialists in agriculture and home economics.

It seems to be the attitude of these young people that they owe some special service to the state which has afforded them educational training and they are ready and willing to pay their debt. In some cases it is probable that teaching will be a stepping stone to some other business or profession, but it does not necessarily lower the standard of service or the professional attitude maintained by our graduates.

Respectfully submitted,
WALTER H. FRENCH,
Professor of Agricultural Education.

REPORT OF THE DIVISION OF VETERINARY SCIENCE.

To the President:—

Sir:—Herewith I present the thirteenth Annual Report of the Division of Veterinary Science.

During the year just closed no changes in the personnel have occurred in the veterinary faculty. Dr. O. A. Taylor has devoted more of his time teaching in the physiology department while Dr. H. E. Johnson has devoted his entire time to the subject of Anatomy.

The department of Surgery and Medicine has conducted the largest clinic which has obtained since the establishment of the Division which is compared in the following chart.

Year	Equine	Bovine	Ovine	Suis	Canine	Feline	Aves.	Misc.	Total	Nature
1921–22	56	86	839	250	88	4	1	1	1,325	Med. Amb.
	103	735	5	1,642	101	11	....	1	2,598	Surg. Amb.
	8	21	5	6	144	7	5	2	198	Med. Hosp.
	137	140	1	12	144	34	2	5	475	Surg. Hosp.
									4,596	Total
1922–1923	122	73	426	343	243	11	....	....	1,217	Med. Amb.
	80	705	2	192	271	15	....	....	1,265	Surg. Amb.
	38	21	403	100	221	18	....	....	1,001	Med. Hosp.
	131	211	8	361	282	33	....	....	1,026	Surg. Hosp.
									4,509	Total

The meeting of the American Veterinary Medical Association at St. Louis, Missouri, was not attended by any member of our faculty, the attitude of the College toward assuming no part of traveling expenses of members of the veterinary faculty in time is responsible for such non attendance.

The International Live Stock Show and meeting of the United States Live Stock Sanitary Association in December was attended by Drs. Chamberlain, Hallman, Hutton and Runnells. The meetings of local Association, the Thumb, Detroit and Adrian have been attended by one or more members of the Division.

The Annual Meeting of the Michigan State Veterinary Medical Association was held February 6th and 7th, 1923. The meeting was better than the one of the preceding year. At the February meeting of the Association by vote changed its Annual meeting to June 26th, 27th and 28th. This was done to draw a larger attendance.

The Forty-First Annual Meeting of the Michigan State Veterinary Medical Association held on June 26th, 27th and 28th was entertained by the College, the gathering was not as large, 133 men and 27 women, as of the two previous years. The smaller attendance might have been expected following as it did the February meeting. The college participated largely on the program.

Attempts to increase the student enrollment last year were in a measure successful with thirteen freshmen. The total enrollment of freshmen veterinary students has not changed from that recorded in the chart prepared by Dean White of the Ohio State University.

1922-1923.

Name of Institution	First Year	Second Year	Third Year	Fourth Year	Special	Totals
Alabama Polytechnic Institute	6	5	8	13	....	32
Colorado Agricultural College	17	14	12	19	2	64
Georgia State Agricultural College	7	7	6	5	....	25
Iowa State Agricultural College	25	22	15	17	....	79
Kansas State Agricultural College	10	14	18	22	1	65
Michigan Agricultural College	13	10	9	7	....	39
New York State Veterinary College (Cornell)	31	11	16	31	3	92
New York State Veterinary College (N. Y. Univ.)	C	L	O	S	E	D
Ohio State University	19	12	15	25	4	75
Ontario Veterinary College (Canada)	17	11	22	37	....	87
University of Pennsylvania	11	11	5	8	2	37
Texas Agricultural and Mechanical College	6	6	2	2	....	16
State College of Washington	6	5	4	4	....	19

A few prospects for next years' class have been referred to Dr. Giltner, the new Head of the Division.

At the June 1923 Commencement seven men received the degree of Doctor of Veterinary Medicine as follows:

Mr. H. S. Atkins.
Mr. D. H. Dickie.
Mr. A. W. Emery.
Mr. S. W. Gingrich.
Mr. W. R. Hinshaw.

Mr. L. H. LaFond.
Mr. F. M. Shigley.

Of the seven graduates, six will enter general practice, one will take up technical work at Kansas State Agricultural College. Also one man, Mr. K. E. Merlau, will finish his work at the end of the summer school and receive his degree as of the class of 1923.

ANATOMY DEPARTMENT.

In the report of the Anatomy Department last year attention was directed to the inadequate housing conditions which have prevailed since the introduction of such work into the Veterinary course. The condition still obtains.

The work of the department including pharmacology and assistance to the physiology department as of last year has been carried on by Drs. Chamberlain, Johnson and Taylor. The chart below shows only the class work done and does not represent the preparation of material for laboratory work.

Subject	No. of students	Credits	Lectures	Laboratory	Total class hours
Fall:					
Anatomy 1a	12	4	26	78	104
Anatomy 2a	14	7	26	195	221
Anatomy 4	19	4	26	78	104
Poultry 2	19	5	13	26	39
Pharmacology 2	8	5	26	78	104
Pharmacology 4a	9	3	39	0	39
Physiology 1	58	2	0	156	156
Totals	139	30	156	611	767
Winter:					
Anatomy 1a	4	4	24	72	96
Anatomy 1b	17	3	12	72	84
Anatomy 2b	11	2	0	72	72
Anatomy 3a	22	4	24	72	96
Poultry 3	16	5	12	24	36
Pharmacology 2a	9	2	24	0	24
Pharmacology 4b	12	3	36	0	36
Physiology 1	67	2	0	144	144
Totals	158	25	132	456	588
Spring:					
Anatomy 1c	15	4	11	99	110
Anatomy 2c	11	2	0	66	66
Anatomy 3b	20	4	22	66	88
Pharmacology 1	10	5	44	22	66
Pharmacology 3	11	4	33	22	55
Physiology 1	9	2	0	44	44
Totals	76	21	110	319	429
Grand Total	373	76	398	1,386	1,784

The chart is self explanatory. As usual many of the Veterinary students have found solution of their irregular classification within the Anatomy department which means many extra hours of instruction not represented. Note in the above chart that Dr. Taylor has about divided his time between pharmacology and physiology. In the reorganization of the Veterinary Division Dr. Taylor his teaching of pharmacology, laboratory supplies and equipment should be transferred to the physiology department. Please note further that Dr. Chamberlain gave three hours weekly during the fall and winter terms assisting with poultry courses in their relation to structure and embryology of poultry. Also he has conducted the affairs of the Dean's office including that the class officer of the Division.

Respectfully submitted,
F. W. CHAMBERLAIN,
Acting Dean of Veterinary Science.

REPORT OF THE DEPARTMENT OF ANIMAL PATHOLOGY.

To the President:—

Sir:—I herewith submit report of the Department of Animal Pathology for the year ending June 30th 1923.

The instruction work for the year was as follows:

Name and Number of Course	Term	Number of Students	Lecture Hours per week	Laboratory Hours per week
Pathology 2a	Fall	8	3	2
Pathology 1	Winter	12	4	6
Disease Control—Dairy Production—Short Course	Winter	29	3	....
Pathology 2b	Spring	10	2	2
Pathology 3	Spring	10	3	2

Following is the record of the Autopsies for the year.

HORSES.

1. Infarct	
Hemorrhagic of lung	1
Strangles	1
Volvulus	
Ileum	1
Total	3

COWS.

Abomasitis with rupture	1
Dilatation of stomach, congenital	1
Enteritis	
Acute catarrhal	1
Intoxication,	
Acute-gastro intestinal	3
Nephritis,	
Chr. Parenchymatous	1
Pericarditis,	
Traumatic	1
Peritonitis,	
Acute Fibrinous	1
Pneumonia	
Necrotic	2
Acute Lobar	3
Poisoning	
Cotton Seed meal	1
Calcium chloride	1
Septicemia	1
Tuberculosis	
Positive	1
Negative	4
Total	22

SHEEP.

Diagnosis not made	2
Gastro-enteritis	
Acute fibrinous	2
Hemorrhagic	1
Helminthiasis	6
Hepatitis Acute supurative	1
Intoxication,	
Acute Gastro-Intestinal	1
Laryngitis,	
Ulcerative	1
Peritonitis	
Acute perulent	1
Pneumonia	
Acute Lobar	2
Embolic	1
Lobular	1
Necrotic	3
Taeniasis	1
Total	23

SWINE.

Cholera	2
Colitis	
Necrotic	1
Ulcerative	1
Diagnosis not made	3
Enteritis	
Catarrhal	1
Necrotic	1
Ulcerative	2
Gastro-enteritis	
Acute Catarrhal	1
Acute Hemorrhagic	2
Helminthiasis	4
Intoxication	
Acute gastro-intestinal	4
Pneumonia	
Acute Lobar	1
Caseous	5
Necrotic	1
Verminous	1
Pyemia	1
Septicemia	1
Strongylosis pulmonary	3
Tuberculosis	1
Total	36

DOGS.

Diagnosis not made	2
Distemper	7
Endocarditis, Chronic	1
Enteritis	
Acute catarrhal	1
Acute hemorrhagic	1
Helminthiasis	1
Hyperplasia,	
Thyroid	1
Intussusception	
Colon	1
Jejunum	2
Rachitis	1
Septicemia	1
Total	19

CATS.

Colitis,	
Ulcerative	1
Distemper	2
Enteritis	
Catarrhal	1
Fibrinous	1
Gastritis, Acute Catarrhal	1
Gastro enteritis, Acute catarrhal	1
Goitre	1
Helminthiasis	1
Peritonitis, acute fibrinous	1
Total	10

RABBITS.

Abscess	1
Total	1

FOWLS.

Abscess	1
Cholera	1
Dessicated Egg in abdomenal cavity	1
Diagnosis not made	12
Enteritis, Acute catarrhal	1
Entero-hepatitis	
Infectious	1
Helminthiasis	3
Hemorrhage	1
Neoplasms	
Carcinoma, squamous cell	1
Fibro-sarcoma	1
Sarcoma	1
Peritonitis	1
Pneumonia	
Acute Lobar	1
Taeniasis	1
Tracheitis,	
Acute purulent	1
Tuberculosis	
Negative	4
Positive	3
Total	35

FOXES.

Diagnosis not made	1
Total	1

TOTAL AUTOPSIES.

Horses	3
Cattle	22
Sheep	23
Swine	36
Dogs	19
Cats	8
Rabbits	1
Fowls	35
Foxes	1
Total Diagnoses	148
Autopsies Repeated	17
Total Autopsies	131

Following is the record of examinations made of material from animals sent to the Department by farmers and veterinarians.

HORSE.

Antemortem	
Rupture of stomach	1
Diagnosis not made	2
Neoplasms	
Fibroma	1
Total	4

COWS.

Acute mammitis	1
Chr. suppurative hepatitis	1
Chr. purulent cystitis	1
Diagnosis not made	4
Neoplasms	
Fibroma	1
Papilloma	1
Pyemia	1
Tuberculosis	
Negative	1
Positive	2
Total	13

SHEEP.

Helminthiasis	1
Pneumonia, Verminous	1
Total	2

SWINE.

Actinomycosis of mammary gland	1
Diagnosis not made	3
Erythema	1
Fat Necrosis	1
Hemorrhage	1
Pork for edibility	2
Tuberculosis	2
Total	11

DOGS.

Acariasis	
Negative	5
Positive	1
Diagnosis not made	1
Total	7

FOWLS.

Diagnosis not made	2
Neoplasms	
Sarcoma	1
Tuberculosis	
Negative	2
Positive	2
Total	7

RABBIT.

Neoplasms	
Papillary epithelioma	2
Total	2

GUINEA PIG.

Chr. Suppurative Orchitis	1
Total	1

TOTAL ACCESSIONS.

Horses	4
Cattle	13
Sheep	2
Swine	2
Dogs	7
Fowls	7
Rabbits	2
Guinea pigs	1
Total	38

Dr. Runnells in addition to his class room and laboratory work, has continued to act as Secretary of the Michigan State Veterinary Medical Association. This work demands a good part of his time but it brings the college into close touch with the profession and should be regarded as one form of extension.

A large part of my time has been devoted to a continuation of the investigations of the diseases of the reproductive organs of cattle.

Respectfully submitted,
E. T. HALLMAN,
Associate Professor of Animal Pathology.

REPORT OF THE DEPARTMENT OF SURGERY AND MEDICINE.

To the President:—

Sir:—I hereby submit my sixth annual report of the Department of Surgery and Medicine for the fiscal year ending June 30, 1923.

The recitation and laboratory work of the department has been handled entirely by Dr. Sales and the writer. The greater part of the ambulatory clinic has been handled by Dr. McKercher. Dr. Sales and the head of the department have also participated in this work.

In addition to the regular work of the department, instruction in Veterinary Science 2a, 2b, and 2c, which is elective for Agricultural and Forestry Courses, has been handled by the Department.

A tabulated report of the instruction work for the school year 1922-1923 is given in the following table.

Subject	Fall Term		Winter Term		Spring Term	
	Recitation hours per week	Laboratory hours per week	Recitation hours per week	Laboratory hours per week	Recitation hours per week	Laboratory hours per week
Surgery 1	4	4				
Surgery 2					2	
Surgery 3	4	4				
Clinic 4a				15		
Clinic 4b						15
Clinic 4e		15				
Clinic 4d				15		
Clinic 4e						15
Surgery 5			3			
Surgery 6			4			
Medicine 1	4					
Medicine 3a			5			
Medicine 3b					4	
Medicine 4a			5			
Medicine 4b					4	
Zoote clinics 1			2	2		
Veterinary Science 2a	5					
Veterinary Science 2b			5			
Veterinary Science 2c					5	
Total	17	23	24	32	15	30

A TABULATED REPORT OF THE MEDICAL HOSPITAL CLINIC FROM JULY 1, 1922 TO JUNE 30, 1923.

	Horses	Cattle	Sheep	Swine	Dogs	Cats
Alopecia					1	
Ascities					1	1
Antony of the forestomachs		2				
Azoturia	1					
Chorea					6	
Colic, spasmodic	14					
Colic, flatulent	1					
Conjunctivitis	2				4	
Constipation	1				6	
Dermititis	1				6	
Diarrhoea					8	
Distemper					96	
Eczema					8	
Endocàrditis	1				2	
Enteritis			1	4	2	2
Fleas					5	2
Gastro-intestional catarrh					2	
Gastro-enteritis	1				22	4
Helminthiasis	1	1 coyote		91	7	4
Hog cholera				2		
Impaction of rumen		1				
Influenza	8					
Intestional intoxication			1			
Jaundice					1	
Laryngitis			1 goose	1 turkey		
Lip and leg ulceration			1			
Lymphangitis	1					
Mange, demodex					22	
Mange, symbiotes		15				
Mange, sarcops	1	1 goat			9	4
Paraplegia		1		2	1	
Phthiriasis					2	
Poison, strychnine					3	
Pneumonia			3	1	2	1
Rachitis					1	
Rheumatism					1	
Rhinitis					1	
Roupe				1 chicken		
Strychnine poison					2	
Strangles	4					
Stomatitis	1					
Stomach worm treatment			397			
Tympanitis		2				
Total	38	21	403	100	221	18

A TABULATED REPORT OF THE SURGICAL HOSPITAL CLINIC FROM JULY 1, 1922 TO JUNE 30, 1923.

	Horses	Cattle	Sheep	Swine	Dogs	Cats
Abortion	1	1				
Abscess	2		2	4	11	2
Amaurosis					1	
Amputation of tail					23	
Arthritis	1	2		1	1	
Atrophy of shoulder muscles (Sweeny)	1					
Atresice of teat		2				
Amputation of accessary digit	1					
Blanitis		1				
Boarding	4	8	1 raccoon		87	2
Bumble foot				1 turkey		
Cystic ovaries		1				
Castration, simple	8	1		68	5	10
Cervicitis		2				
Concussion of spinal cord					1	
Contusion	2	1		1	6	
Coxitis					1	
Cystitis		1	2			
Conjunctivitis		1				
Dehorning		13				
Destroyed					9	11
Dystocia			2	1	2	1
Distemper vaccination					2	
Ear trimming					4	
Elephanthiasis	1					
Examination for pregnancy		4				
Empyema of frontal sinus		1				
Fistule withers	2					
Fracture, femur					2	
Fracture, humerous					1	
Fracture, metacarpus						1
Fracture, tibia					1	
Fracture, pelvis	1					
Gonitis			1			
Grease heel	1					
Hare lip					1	
Hematoma		1			2	1
Hemorrhagie septicemia vaccination		23				
Hernia, umbilical	1					
Hernia, scrotal				3		
Hernia, Ventral				1		
Hog cholera vaccination				280		
Impaction of crop			1 turkey			
Keratitis	4	1			4	
Lameness, shoulder	3					
Laminitis	1					
Luxation of patella		2				
Mastitis		7				
Metritis		6				
Mallien test	43					
Orchitis					1	
Otitis					12	
Ovariectomy	1				83	5
Open joint	1					
Panaritum		1				
Papillitis					1	
Paralysis, facial			1			
Parophymosis					1	
Parotitis	1				3	
Periodic oplholmia	4					
Phlegmon					1	
Polypus, nasal	1					
Prolapse vagina					1	
Pyometra		1				
Paraplegia					1	

A TABULATED REPORT OF THE SURGICAL HOSPITAL CLINIC.—*Continued.*

	Horses	Cattle	Sheep	Swine	Dogs	Cats
Prevous urachus	2					
Pyemic arthritis	1					
Quarter crack	1					
Rabies vaccination					1	
Retained placenta		8				
Ringbone	1					
Soft Crop			1 turkey			
Sharp teeth	15					
Spavin, bone	1					
Sterility		10				
Scratches	1					
Tendenitis	1					
Teat stricture		1				
Teeth extraction	2					
Trimming toenails					1	
Tuberculin test		108				
Tumors, unoperatable	1		1 rabbit			
Tumors, operatable	3	1			1	
Umbilical hernia	2					
Wound, caustic					1	
Wound, Contused	1			1	1	
Wound, incised	2			1	3	
Wound, lacerated	6	1 canary	bird		5	
Wound, puncture	6	2			1	
Total	131	211	8	361	282	33

A TABULATED REPORT OF THE MEDICAL AMBULATORY CLINIC FROM JULY 1, 1922 TO JUNE 30, 1923.

	Horses	Cattle	Sheep	Swine	Dogs	Cats
Antony of the forestomachs		9				
Anarexia	3					
Azaturia	4					
Auto-intoxication		3			1	
Abortion		1				
Ascites					1	
Bronchitis					1	
Colic, spasmodic	8					
Colic, engorgement	1					
Colic, flatulent	3					
Colic, impaction	3					
Conjunctivitis		2				1
Cystitis	1					
Chorea					4	
Caryza	1					
Cow pox		1				
Constipation					3	
Distemper					126	
Distemper vaccination					27	
Diarrhoea					9	
Enteritis		2	1		1	
Eczema					4	
Eclampsia					4	
Gastro-enteritis		7		1		2
Goiter		1			1	
Gastro-intestinal catarrh	19	3		3	17	3
Helminthiasis				250	7	1
Hog cholera				87		
Hemorrhagic septicemia		10				
Impaction of Rumen		6				
Influenza	36					
Intestinal intoxication						1
Jaundice					1	
Lumphangitis	12					
Lead Poisoning		5				
Mange, demodex					22	
Mange, sarcops						
Mastitis		2				
Necro bacillosis		2				
Otitis					5	
Periodic opthalmia	2					
Parturient paresis		5				
Pneumonia	8	3	1			
Paraplegia	1	2			2	
Psoriasis	1					
Ptomaine poison					1	2
Poison, strychnine					3	
Rheumatism			1	2		
Rachitis					1	
Senility					2	1
Strangles	1					
Stomach worm treatment			422			
Tetanus	14					
Tympanitis		2				
Tuberculosis		6				
Traumatic pericarditis		1				
Urticaria	1					
Vertigo	3					
Total	122	73	426	343	243	11

A TABULATED REPORT OF THE SURGICAL AMBULATORY CLINIC TREATED FROM JULY 1, 1922 TO JUNE 30, 1923.

	Horses	Cattle	Sheep	Swine	Dogs	Cats
Abortion	2	2				
Abscess		8			7	
Atrophy of shoulder muscles (Sweeny)	3					
Amputation of tail					26	
Arthritis	4					
Atresia of teat canal		2				
Atresia of cervix		1				
Bruised heel	2	1				
Bull ringing		1				
Bone spavin	2					
Castration, simple	3	3	1 monkey	23	4	11
Contusion	12	5		1	5	1
Choke	2	1				
Cystic ovaries		1				
Dehorning		19				
Dystocia		11		4	3	1
Dermatitis	1				7	
Empyemia of sniceses		2				
Ear trimming					13	
Examination for pregnancy					2	
Fistula of withers		2				
Fracture of tibia		2				
Fracture of pelvis		1				
Fracture of radius					3	
Fracture of ribs		2				
Fracture of illium					2	
Fracture of facial bones	2					
Fracture femur	1				3	
Fracture scapula					6	
Fistula of teat		1				
Goiter					1	
Gonitis	1					
Hematoma	2	4				
Hemorrhagic septicemia vaccination		24				
Hog cholera vaccination				158		
Keratitis	2	1			2	
Laminitis, chronic	3					
Mastitis	8	14	1	1		
Metritis	4	4				
Nail in the foot	6					
Navicular disease	3					
Ovariotomy					63	2
Prolapse of uterus		1				
Pododermititis	1					
Parturient paresis		2				
Phlebotomy		7				
Prolapse of anus				1		
Prolapse of vagina			1	2		
Pyometra		1				
Paraplegia			1 rabbit		2	
Prolapse of rectum				1		
Retained placenta	1	35				
Rupture of stomach	1					
Sharp teeth	7					
Sterility		4				
Saddle gall	1					
Shoe boil	1					
Splint	1					
Shoulder lameness	1					

A TABULATED REPORT OF THE SURGICAL AMBULATORY CLINIC TREATED.—*Continued.*

	Horses	Cattle	Sheep	Swine	Dogs	Cats
Tendenitis	2					
Tuberculin test		534				
Teeth extraction	2				1	
Thoroughpin	2					
Teat stricture		1				
Tumor, operatable				1		
Ulcer	1					
Vaccination, white scours		4				
Vaginitis					1	
Wound, lacerated	7	5			11	
Wound, puncture	11	3			5	
Wound, contused	4				3	
Wound, incised					99	
Total	80	705	2	192	271	15

The total number of animals treated by the department during the school year 1922-1923 including both ambulatory and hospital clinic was 4,323. Out of this number 371 were horses, 1,010 cattle, 839 sheep, 996 swine, 1,017 dogs, 77 cats, 1 monkey, 2 rabbits, 1 coyote, 1 goose, 4 turkeys, 1 goat, 1 chicken, 1 raccoon, and 1 canary bird.

The total number of ambulatory cases treated during the school year was 2,485 and the total number of surgical and medical hospital cases treated was 1,838, an increase of 1,201 cases over last year.

The large number and variety of cases available for instruction purposes has been exceedingly satisfactory and the clinic is constantly growing bigger and better each year.

Respectfully submitted,
JOHN P. HUTTON,
Associate Professor of Surgery and Medicine.

REPORT OF THE REGISTRAR.

To the President:—

Sir:—I have the honor to present the following report of the Registrar's Office for the year ending June 30, 1923.

In the regular college courses the enrollment for the year is as follows:

	Men	Women	Total	
Agriculture and Forestry	526	8	534	....
Engineering	531	1	532	....
Home Economics	....	395	395	....
Applied Science	124	35	159	....
Veterinary	42	....	42	....
Total	1223	439	1,662	1,662
Summer School	273	117	390	....
Graduate Course	47	8	55	....
Total	320	125	445	445
SHORT COURSES:				
Two-year sixteen weeks' course in Agriculture	71	....	71	....
Two-year eight weeks' course in Agriculture	32	....	32	....
Eight-weeks' course in Horticulture	25	....	25	....
Eight-weeks' course in Farm Engineering	9	....	9	....
Twelve-weeks' course in Dairy Husbandry	28	....	28	....
Twelve-weeks' course in Dairy Manufactures	12	....	12	....
Eight-weeks' course in Poultry Husbandry	15	3	18	....
Two-weeks' course in Ice-cream Making	8	....	8	....
Four-weeks' course in Truck and Tractor	20	....	20	....
Special Courses	4	....	4	....
Total	224	3	227	227
Vocational Guidance School	88	....	88	88
Total in all courses	....	....	....	2,422
Names repeated	....	....	....	219
Net Total	....	....	....	2,203

ENROLLMENT BY TERMS

Course	Fall	Winter	Spring	Summer
Agriculture and Forestry	502	494	455	128
Engineering	514	473	444	69
Home Economics	384	352	336	79
Applied Science	137	138	133	18
Veterinary	37	31	31	12
Graduate	37	45	40	15
Summer Session Students—General	....	....	....	50
Rural Teachers	....	....	....	8
Special 10-weeks' Agricultural Course for Superintendents	....	....	....	11
	1,611	1,533	1,439	390

ENROLLMENT BY CLASSES

	Agr.		For.		Engr.		H. E.		Sci.		Vet.		S. S.		Total	
	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W
Graduates	44	1	....	....	3	....	....	7	....	....	....	....	....	....	47	8
Seniors	103	2	19	....	92	....	....	74	4	1	10	....	....	....	228	77
Juniors	73	1	22	....	97	....	....	71	16	4	5	....	....	....	213	76
Sophomores	99	3	29	.	138		.	101	49	12	10		.	.	325	119
Freshmen	179	....	....	....	201	1	....	141	51	17	17	....	....	....	448	159
Specials	2	2	....	....	3	....	....	5	4	1	....	....	....	....	9	8
Summer Session	....	....	....	....	....	....	....	....	....	....	....	....	262	109	262	109
Rural Teachers														8		8
Special 10-weeks' course													11		11	
	500	9	70	....	534	1	....	402	124	35	42	....	273	117	1543	564

GEOGRAPHICAL DISTRIBUTION OF STUDENTS IN FOUR YEAR AND GRADUATE COURSES

Armenia	1	Minnesota	2
Canada	2	Mississippi	2
China	1	Missouri	2
Colorado	1	New Jersey	1
Delaware	2	New Mexico	1
Denmark	1	New York	15
District of Columbia	1	Ohio	26
Egypt	2	Pennsylvania	8
England	1	Philippine Islands	1
Illinois	19	Puerto Rico	1
Indiana	11	South Dakota	1
Iowa	3	Tennessee	1
Kansas	1	Texas	1
Kentucky	2	Turkey	2
Maryland	3	Virginia	1
Massachusetts	1	West Virginia	2
Michigan	1,592	Wisconsin	6
			1,717

STUDENTS ENROLLED DURING THE YEAR 1922–1923.

Number Enrolled:

Agricultural and Forestry Course	186
Engineering Course	209
Home Economics	164
Applied Science	83
Veterinary Medicine	18
Graduate	21
Total	681

Preparation.

Graduates of Accredited High Schools	544	
High School Credits and Examinations	8	
Credits from Other Colleges	83	
Federal Preparatory	46	
Total		681

DEGREES GRANTED JUNE 18, 1923.

Bachelor of Science.

a, Agriculture; e, Engineering; h, Home Economics; f, Forestry; s, Applied Science

Clyde Allen, a
Lester John Allen, a.
George Porter Arnold, a.
Dorothy Isabel Bacon, h.
Katheryn DeVos Baert, h.
Paul Moore Barrett, a.
Carl Frederick Behrens, a.
Lauren Simeon Billings, a.
Herbert Hugh Birch, f.
John Frederic Bissinger, a.
Henry Kenneth Blakiston, a.
Clyde Bohl, e.
Gordon Elwood Bonine, a.
Evans Roy Bowins, a.
Cyrus Alden Boyer, a.
Harold Boyer, e.
Helen Gladys Bradford, h.
Hester Rosabel Bradley, a.
Jacob Orval Brady, a.
Kathryn Lou Branch, h.
Robert Frederick Brevitz, f.
Calvin Allison Brown, e.
Edith Orilla Brown, h.
Edwin Jay Brown, e.
Richard Bruce Buckingham, e.
Floyd William Bueschlen, s.
Lee James Bullen, e.
Fred Howard Bunnell, e.
Margaret Elizabeth Campbell, h.
David Glenn Carnegie, f.
Cameron John Carruthers, a.
Charles Homer Cash, e.
Aurel Alvin Catlin, e.
Ruth Alma Chamberlin, h.
Albert Charles Christensen, a.
Jessie Eugenia Church, h.
Marian Ward Clark, h.
Charles Russell Clausen, a.
Albert Baldwin Cook, a.
Clayton McKellar Cook, a.
Walter Alfred Cook, e.
Huldah Jane Coon, h.
Forest B. Crampton, e.
Margaret Campbell Crozier, h.
Burwell Cummings, a.
John Bernard Dakin, e.
Leslie Carleton Davies, e.
Arthur Jacob Davis, e.
Charles David Davis, e.
Ellsworth Wallace Davis, e.
Viva Lucile Davis, s.
Alice Virginia Decker, h.
Leona Marie DeYoung, h.
Arthur Dinsmore, a.
Florence Marie Doyle, h.
Elvin David Dressel, f.
Grace LaVerne DuBois, h.
Dorotha Crawford Dutton, h.
Jay Dykhouse, a.
Joseph Bailey Edmond, a.
Robert Kelsey Edmonds, e.
Harold Hildreth Every, a.
Keith Mallory Farley, e.
Carl George Fenner, f.
Clarence Wilfred Fessenden, e.
Faye Fern Foster, h.
Ivan Philo Galpin, a.
Julia Elsie Gelinas, h.
Robert Wallace Gerdel, a.
Helen Marion Gibson, h.
Marguerite Jean Gorman, h.
Helen Lucile Gould, h.
Howard Carlysle Graham, e.
Harry Cornelius Graves, a.
Emmet Hague Greenwood, e.
Mildred Katherine Grettenberger, h.
Forrest Leonard Grim, a.
Lucile Grover, h.
James Harold Haigh, e.
Mary Dorothy Hanigan, h.
John Alfred Hannah, a.
Wilson Dale Harbison, a.
Leo Kern Harris, e.
Harold Russell Heathman, f.
Lynn George Heatley, a.
Helen Elizabeth Hedrick, h.
Waino John Helli, a.
Carl Harvey Hemstreet, a.
Fred Worcester Henshaw, s.
Emily Herkimer, h.
Marie Bentley Higbie, h.
Roy Melvin Hodges, e.
Ellsworth Burnett Holden, a.
John Der Hovhannesian, a.
Lloyd Ingersoll Hughes, e.
John Sherman Hyde, a.
Austin Oliver Ingersol, e.
George Irvine, a.
James Howard Jacklin, a.
William E. Jacobs, e.
Dorothy Adaline Jermin, h.
Charles Edward Johnson, a.
Fred McCoy Johnson, e.
Dewey Manila Judd, a.
Melita Elizabeth Kaiser, h.
David Noble Kee, f.
Margaret Helen Keller, h.
Kenneth Ross Kerr, a.
Ralph Wyman Kidder, a.
John Henry Killmaster, a.
Ernest Allen Kinney, e.
Victor Henry Kinson, a.
John Arthur Kloha, e.
Roy Walter Knopf, a.
Paul Wilhelm Albert Koepnick, e.
Ralph August Koppana, e.
Benjamin William Lafene, a.
Marion Willoughby Landon, e.
Katherine Hollister Langley, h.
John Bouton Lazell, e.
Clifford Boynton Lewis, a.
Werner H. Lewis, e.
John Griffin Little, e.
Hazel Josephine Loomis, h.
Arthur Edward Lukowski, e.
Morris Kennedy MacGregor, a.
Edith Elizabeth McNeil, h.
Carmen Valerie Maas, h.
Earl Dewey Mallison, a.
Gerald Edwin Mallory, a.
Sigurd Tobias Mathieson, a.
Hubel William Matzinger, e.
Howard Kenneth Menhinick, a.
Walter Irish Meyers, f.
Donald Cooper Millard, e.
Kathleen Diadama Miller, h.
Neil Joseph Miller, e.
Theodore Roosevelt Miller, f.
Lucius Howard Moore, a.
Ralph Ray Morningstar, e.
Neil Bailey Morrish, e.
Earl Lione Morrison, e.
Gordon Morrison, a.
Russell Alger Morrison, e.

Alice Rhodes Mulchahey, a.
Leslie James Nason, e.
Fenton Theodore Neller, e.
Francis Elizabeth Neuman, h.
Marian B. Notley, h.
Leslie Scott Oldman, e.
George William Olson, f.
Russell Hugh O'Neil, f.
Kenneth Ousterhout, a.
Willard Henry Pangborn, a.
Howard Everett Parson, a.
Walter Fred Patenge, e.
Margaret Jane Patterson, h.
Andrew Henry Pekuri, a.
LaRue Evelyn Pennell, h.
James Ward Percy, e.
Lester Elsworth Perrine, e.
Seymour Mason Perry, a.
Robert Karl Phelps, e.
Felix Aquino Pineda, a.
Vernon Chester Pino, e.
Henry Arthur Platz, e.
Roman Joseph Pohl, e.
George Postmus, a.
Philip Daniel Prentice, e.
Merrill Anson Pringle, a.
Edward Arden Pryce, e.
Matthew James Quirk, e.
Milo J. Ralston, a.
Charles Wesley Ralya, a.
Harold Edwin Rankin, a.
Gerald Morris Reams, e.
Charles L. Richards, f.
Eleanor Powers Richey, h.
Donald G. Rieman, a.
Carl Herbert Ripatte, f.
Durward Robson, f.
Howard J. Root, e.
Theodore John Rosevelt, a.
Loren Stauffer Ross, a.
Oran Wilbur Rowland, a.
Burrell Franklin Ruth, e.
Dorothy Sanford, h.
Howard Ray Sayre, f.
Ward Robert Schafer, e.
Harold Manz Schaibley, e.
Clyde Schilhaneck, a.
Herbert William Schmidt, e.
Minnie Helen Schmidt, h.
Albert Peter Schweizer, e.
Leona Vivian Scully, h.
Arthur William Seeburger, e.
Mildred Ione Seymour, h.
Gregory Andreivitch Shadko, e.
Ethel June Sharp, h.
Earl Adam Sindecuse, a.
Henry Franklin Small, e.
Robert Burns Small, a.
Avis Augusta Smith, h.
Harry George Smith, e.
Colonel Francis Snyder, e.
Margaret Elizabeth Snyder, h.
Carl Walter Soderbeck, e.
John Franklin Spalding, e.
Robert Dugan Spencer, e.
Ezra Ferdinand Sperling, e.
Zora Lomilla Staudacher, h.
Douglas Van Steere, a.
Hilda Roscilla Stein, h.
Martha Carolyn Steward, h.
John Ronald Stewart, e.
Mason Cramer Stiff, e.
Leah Esther Stoll, h.
Hugo T. Swanson, a.
Isabel Blair Taylor, h.
William Hall Taylor, a.
L. C. Terwilliger, e.
Madeline Elizabeth Thompson, h.
Gustav Adolph Thorpe, a.
Emogenia Paula Thurman, h.
Paul Edward Tilford, a.
Carl Emerson Topping, e.
Frank Willis Trull, a.
Percy John Truscott, e.
Ralph Payne Turner, e.
Leonardus Michel Zwightman Van Noppen, e.
Richard Owen Van Orden, e.
Clara Louise Van Winkle, h.
Nathalia Agatha Vasold, h.
Berneda Pauline Walker, h.
Clair Smith Waltman, a.
John Sheriff Watson, a.
Philip Edwin Weamer, a.
Lucile Wellman, h.
Sarah Elizabeth West, h.
Mary Kathryn Wible, h.
Clair Frank Wickman, a.
Harold Beeri Wilcox, a.
William A. Luther Willard, a.
Irene Elizabeth Wilson, h.
Warren Seeley Wixom, e.
Ralph Nelson Wright, a.
Verno O. York, e.
Ming Tat Young, a.
William Joseph Zeber, e.
Ruth Aileen Zorman, h.

DOCTOR OF VETERINARY MEDICINE.

Hazen S. Atkins
Donald Hugh Dickie
Ashton William Emery
Sherman Wesley Gingrich
William Russell Hinshaw
Louis Henry LaFond
Fred Martin Shigley

MASTER OF SCIENCE.

Hubert McClure Brown
Myron A. Cobb

MASTER OF AGRICULTURE.

Howard Robert Estes
Donald William Francisco
Herman Joseph Gallagher

MASTER OF HORTICULTURE.

Austin Lester Pino

MASTER OF FORESTRY.

John Conley DeCamp
John Baptiste Maas

CIVIL ENGINEER

Edwin Herman Pate
Chester Earl Thompson
Jacob Van Buren

MECHANICAL ENGINEER

Henry Elwood Aldrich
Oscar William Fairbanks
George William Hobbs.

DOCTOR OF VETERINARY MEDICINE (Honorary).

Herman H. Halladay

DEGREES GRANTED NOVEMBER 1, 1922.

MASTER OF SCIENCE

Wilfred Douglas Mills

MASTER OF AGRICULTURE

Charles Albert Willson

DEGREES GRANTED JANUARY 30, 1923.

BACHELOR OF SCIENCE.

Murrel Leonard Bailey, a
Robert A. Bevier, f
Olive Clinton, h
Irving Jerome Gillette, a
Irene Marguerite Hale, h
Helen Hartough Halsted, h
Edward William Hardies, a
Frederick Harvey Knox, a
Clare F. Jolley, a
Josephine Matthews, h
Glenn Winton Nesman, a
Lucile Maud Reach, h
Ansel Milton Shaw, a
Ralph Heath Sill, a
Leonard Ray Vear, a
Allan Raymond Weber, f
Melvin deVar Westcott, a
Roscoe Howard Wightman, a
Vernon Edward Willard

SUMMARY OF DEGREES GRANTED DURING THE YEAR 1922–1923.

BACHELOR OF SCIENCE.

Agricultural Course	99	
Engineering Course	83	
Forestry Course	17	
Home Economics Course	67	
Applied Science Course	3	
Total		269
Doctor of Veterinary Medicine	7	
Master of Science	3	
Professional Degrees	13	
Honorary Degrees	1	
		24
Total		293

During the past year several new plans have been put in operation which have been helpful to this office as well as to the entire college. One, the "blanket fee" plan, by which students pay a fixed amount each term according to the course taken, has not only saved a considerable amount of clerical work in both the Registrar's and Secretary's Offices, but has enabled the student to know in advance the exact amount of his fees for the year.

Another innovation, that of pre-registration and classification of students, has not yet been in operation sufficiently long to enable us to judge accurately of its benefits. We think, however, that it will result in a more intelligent and careful consideration of the needs of the different students by the classifying officer than could be possible under the old arrangement.

The demands upon this office for statistics, various kinds of information, and data relating to students and faculty are steadily increasing. Needs of this sort could be more easily met if more office space was available. Our present quarters are badly crowded and at certain times of the year it is almost impossible to handle the work in anything like an efficient manner.

Both Miss Anna Ferle, the Assistant Registrar, and Miss Lillian Harrington, Clerk, have rendered valuable service throughout the year and we are glad to be able to retain them for the coming year.

Respectfully submitted,
ELIDA YAKELEY,
Registrar.

REPORT OF THE LIBRARIAN.

To the President:

Sir:—I have the honor to present the following report on the library for the year ending June 30, 1923.

The total number of additions to the library during the year was 1,230 bound volumes and 323 unbound volumes and pamphlets. Of bound volumes 798 were purchased, 345 came by binding, and 87 were gifts, for which we are indebted as follows:

American Iron and Steel Institute, 1.
"Art of Table Setting."
China Board of Trade, 1.
Cuba, 1.
DePew, Hon. Chauncey, 1.
Friday, President, 1
Home Econ. Dept., 3.
Illinois, 1.
Internat. Apple Shippers Assn., 1.
Johnston, Prof. W. W., 3.
Knights of Columbus, 17.
Macmillan Co., 2.
McDaniels, Miss Euhenia, 12.
Michigan, 15.
N. Y. Education Dept., 6.
N. Y. Edison Co., 1.
Pennsylvania, 2.
Relton, F. A. 1.
Roseboom, Mrs. B. 1.
Railroad Problem.
Smith, K. S., 4.
Smithsonian Institution, 5.
Successful Farming Pub. Co., 1.
Stokes, The right to be well born.
U. S. Dept. of Agriculture, 3.
U. S. Commerce Dept., 1.

U. S. Education Bureau, 4.
U. S. Steel Corporation, 1.
"What Prohibition Has Done for America."

Since pamphlets and unbound volumes were acknowledged when received, individual mention is omitted.

In the library reading room are placed the periodicals purchased by the college, numbering 282 publications, foreign and domestic, and, in addition to these may be found the following publications received either as gifts from the publishers or in exchange for our own publications.

Aberdeen-Angus Journal.
Agrl. and Industrial Progress in Canada.
Agrl. Gazette of Canada.
Agrl. Gazette of N. S. Wales.
Agrl. Review.
Agrl. Statistics.
Allegan Gazette.
Alpha Phi Quarterly.
America.
Amer. Bankers' Assn., Journal.
Amer. Co-operative Journal.
American Economist.
American Farm Bureau Federation, Weekly News Letter.
American Farming.
American Fruit Grower.
American Hebrew.
American Issue.
Amer. Journal of Nursing.
Amer. Miller.
Amer. Oxionian.
Amer. Philos. Society, Proc.
Amer. Poultry Advocate.
Amer. Seedsman.
Amer. Swingherd.
Australasian.
Australia Museum Record.
Australia Dept. of Agr. Jl. of S. Australia.
Australia Dept. of Agr. Jl. of Victoria.
Baking Technology.
B. C. A. News.
Bell Telephone Quarterly.
Bean bag.
Belding Banner News.
Berkshire World & Cornbelt Stockman.
Better Farming.
Better Fruit.
Boletin de Agriculture, Sao Paulo.
Boston Museum of Fine Arts, Bulletin.
Brooklyn Botanic Garden, Leaflets.
Brooklyn Botanic Garden, Record.
Buick Bulletin.

Burton Historical Collection, Leaflets.
California, Agr. Dept. Monthly Bulletin.
Calif. Acad. of Science, Proc.
Calif. Citograph.
Calif. Univ. Pub. in Agricultural Sciences.
Calif. Univ. Pub. in Zoology.
Canadian Horticulturist.
Carnegie Institution of Washington, Publications.
Chase Economic Bulletin.
Chester White Journal.
Christian Science Journal.
Christian Science Monitor.
Christian Science Sentinel.
Cloverland Magazine.
Commerce Monthly.
Commerce Reports.
Congressional Record.
Congressional Digest.
Constitutional Review.
Dairy Farmer.
Dairy Record.
Dakota Farmer.
Detroit Educational Bulletin.
Detroit Dept. of Street Railways, Income Statements and Operating Statistics.
DuPont Magazine.
Duroc Bulletin.
East Lansing Community Life.
Eaton Rapids Journal.
Educational Record.
Electric Traction.
Electrical Trade.
Elgin Dairy Report.
Facts About Sugar.
Farm and Home.
Farm and Fireside.
Farm Journal.
Farmer's Advocate.
Farming, the Business Magazine.
Farmington Enterprise.
Field.
Florida Entomologist.
Flour and Feed.
Flower Grower.
Forbes.
France-Etats-Unis.
Fruit Belt.
Fuels and Furnaces.
Grand Rapids Public Library, Bulletin.
Guernsey Breeders' Journal.
Hampshire Advocate.

Hawaiian Forester.
Hoard's Dairyman.
Holcad.
Il Gloriale d'Italia Agricolo.
India. Agrl. Journal.
  Agr. Dept. Reports.
  Research Dept. Reports.
  Research Institute of Pusa, Agrl. Journal.
  Research Institute of Pusa, Bulletins.
  Memoirs, Bacterial Series.
  Memoirs, Botanical Series.
  Memoirs, Chemical Series.
  Memoirs, Entomological Series.
Indiana Farmer's Guide.
Indians' Friend.
Indicator.
Industrial Power.
Ingham County News.
Inter-America.
International Conciliation.
International Institute of Agriculture, Rome. Various publications.
International Rotary Magazine.
Investment Bankers' Assn. of America, Bulletins.
James' Barn Magazine.
Japan, College of Agriculture, Journal. (Imperial Univ. of Tokio.)
Japan, College of Science Journal. (Imperial Univ. of Tokio.)
Jersey Bulletin.
John Hopkins University Circulars.
Jonesville Independent.
Journal of Agrl. Research.
Journal of Agriculture and Horticulure.
Journal of Textile Institute.
Lister Institute of Preventive Medicine, Collected Papers.
Library Service.
Livestock Report, (Clay Robinson).
Market Growers' Journal.
Market Reporter.
Message of the East.
Mexican Review.
Miami Conservancy Bulletin.
M. A. C. Record.
Michigan Business Farmer.
Michigan Farmer. (We also received a bound volume for 1922.)
Michigan History Magazine.
Michigan Library Bulletin.
Michigan Patron.
Michigan Agriculturist.
Michigan Milk Messenger.
Michigan Potato Growers' Exchange.
Midland Naturalist.
Midland Sun.

Ministry of Agri. (London) Leaflets, Special Leaflets, Miscel. Publications, Food production, and Section volume.
Moderator Topics.
Missouri Botanical Garden, Annals.
Monthly Crop Reporter.
New Armenian.
National Education Assn. Bulletin.
National Farmer.
National Grange Monthly.
National Provisioner.
National Stockman and Farmer.
National Weather & Crop Bulletin, *Now* Weather, Crops and Markets.
National Farmer.
Nature Study Review.
N. Y. Botanical Garden, Bulletins.
N. Y. Meteorology, (Draper's Hourly Readings).
North American Veterinarian.
Official Gazette, U. S. Patent Office.
Ohio Farmer.
OK Poultry Journal.
Orange Judd Farmer.
Pacific Dairy Review.
Pan American Union, Bulletin.
Philippine Bureau of Science. Reports.
Potato Digest.
Potato Magazine.
Poultry Guide.
Panama. Canal Record.
Philippine Agriculture Review.
Philippine Agriculturist and Forester.
Power Farming.
Prairie Farmer.
Professional Engineer.
Progressive Farmer and Southern Farm Gazette.
Public Health Reports, from U. S. Marine Hospital.
Reclamation Record.
Reliable Poultry Journal.
Rhodesia Agricultural Journal.
Rice Institute Pamphlet.
Rockefeller Institute for Medical Research, Studies.
The Rotarian.
Russian Information Bureau in the U. S., Bulletin.
Revista Agricola.
Saturday Evening Post. (Miss McDaniels.)
Saulte St. Marie News.
Soo Times.
State Plant Board of Florida, Quarterly Bulletin.
School Life.
Science and Industry, (Australia).
Seed World.
Smithsonian Institution, Bulletins U. S. N. Museum.

Smithsonian Institution, Contrib. to the U. S. National Herbarium.
Smithsonian Institution, Miscel. Collections.
Successful Farming. (Bound vol. also received).
Sultanic Agrl. Society. (Egypt) Bulletins, Technical section.
System on the farm.
Union Bulletin.
Union of South Africa, Dept. of Agr. Journal.
U. S. Dept. of Agri. Bureau of Plant Industry. Current author entries.
U. S. Dept. of Agriculture, Public Roads.
U. S. Dept. of Agriculture, Monthly weather review.
U. S. Library of Congress, Catalogue of state publications.
U. S. Supt. of Documents, Monthly Catalogue of Public Documents.
Vocational Summary, U. S.
Wallaces' Farmer.
Washington Farmer.
Washtenaw Post.
Weekly News Letter.
West Indian Bulletin.
Wilson Bulletin.
Wellcome Tropical Research Laboratories, Bulletins, Chemical Section.
  Bulletins, Entomological Section.

For many years certain foreign publications have been received with more or less regularity, during the year a "periodical" card listing titles, has been made and filed with the card catalogue.

The publications of the U. S. Dept. of Agriculture, and the bulletins of the various state experiment stations, with the U. S. Dept. of Agriculture card index are received and filed in the library. We also receive the catalogues of the leading educational institutions in exchange for our own catalogue.

We are glad to acknowledge our indebtedness to the libraries of the U. S. Dept. of Agriculture, The University of Michigan, University of Chicago, the John Crerar library, the Johns Hopkins, library, Library of Congress and the Library of the U. S. Surgeon General of the U. S. for their courtesy in loaning to us certain publications needed by our research workers.

The circulation of books has greatly increased in number. 11,508 volumes having been loaned during the year for home use, an average of 959 volumes per month. The largest circulation for any one month was 1,257 books; the smallest number, 282 volumes were loaned in August of 1922.

The work of the package library is growing. During the year 91 packages were sent out, and many more were used at the college. This service seems to be more and more appreciated.

Early in September Mr. T. G. Lindquist, assistant in the library, resigned. He was succeeded by Mr. Herbert Patriarche, who served from Oct. 1st until late in December, when he passed away, after an illness of one week. During his short service he made many friends at the college and in the community. Miss Ruth McKinley, a graduate of this college, came to the library on Jan. 1st. She brought with her an experience of four years in the Detroit Public Library, and is giving splendid service. Mr. LeRoy Stegman, who also joined the library staff in January, is giving good service. To the entire staff I desire to express my appreciation of earnest effort under most trying conditions. The new building, now under construction, and which will be ready early in the coming year, will render library service much more attractive, and, we hope, more efficient.

Mr. Hinshaw, our student assistant, was graduated this year. We are sorry to lose him.

The library of the Experiment Station grows but slowly. During the year, 249 volumes were added, of which 8 were purchased, 3 were gifts, and 238 came by binding. The Station library now numbers 5,328 volumes. The college numbers 43,770 volumes. Total in both libraries, 49,098 volumes, which does not include volumes received from the U. S. Supt. of Documents as a depository library.

Respectfully submitted,
LINDA E. LANDON,
Librarian.

REPORT OF THE DEPARTMENT OF HEALTH SERVICE.

To the President:—

Sir:—We submit the following report of Health Service activities at the Michigan Agricultural College from Oct. 1, 1922 to June 18, 1923.

Medical examinations were given to all new students at the beginning of the school year, and also to a large number of Short-Course students throughout the winter term.

In January all students were given smallpox vaccination, due to the fact that a case of it was reported on the campus.

An epidemic of Septic Sore Throat began in the fall term, and lasted during the winter term; also an epidemic of scarlet fever occurred during the winter term. This, along with the smallpox vaccination, gave a great deal of added expense to this department.

In the latter part of January, it became necessary to seek further room for the hospitalization of students. One of the girls' dormitories was used for this purpose for about two months.

This has been a very satisfactory year professionally on account of the multiplicity of ailments, and a very satisfactory one personally, as all students returned home well. The Health Service wishes to thank Mr. Halladay especially for his kindness and his co-operation at all times during the year, and think your Honorable Board owes him a vote of thanks for his kindness to the students while sick.

Respectfully submitted,
A. BORLAND, M. D.,
Director of Health Service.

STATISTICAL.

	Men	Women	Total
Dispensary Calls	5709	765	6474
Room Calls			102
Hospital Bed Patients	209	54	263
Hospital Days	2005	295	2300

Appendicitis, Acute	2
Adhesions, intestinal	1
Arthritis	4
Bronchitis	9
Burn and infection	1
Cellulitis	2
Conjunctivitis	2
Conjunctivitis, purulent	7
Diphtheria	1
Diphtheria, atypical	1
Erythema multiforma	1
Erysipelas	1
Fracture and sprain, ankle	1
Fracture, hip	1
Furuncle	2
Gastritis	12
Gastro-enteritis	3
Goitre, toxic	1
Hysteria	1
Infective Dermatitis	2
Infection, local	4
La Grippe	28
Laryngitis	3
Neuralgia, intercostal	1
Otitis media	4
Observation	6
Pharyngitis	7
Post-Operatives:	
Tonsillectomy	16
Mastoid	2
Rib resection	1
Draining of sinus	2
Post-Oper. Stitch Abscess	1
Parotiditis	7
Pleurisy	2
Pneumonia	5
Ptomaine Poisoning	1
Quinsy	3
Rest	3
Scarlet Fever	50
Scabies	9
Septic sore throat	44
Sprain, ankle	1
Sinusitis, frontal	2
Tachycardia	1
Tonsillitis	3
Typhoid fever	1
Vaccination reaction	1
Whooping cough	1

CLINIC REPORT—1922-1923.

Acne	8
Abscess	15
Abrasions	62
Adenitis	4
Adhesions, intestinal	1
Alopecia	2
Amputation of finger	1
Aortic disease	6
Appendicitis, acute	16
Appendicitis, chronic	5
Arthritis, acute	16
Arthritis, iliosacral	8
Asthma	3
Broken arch, inner	6
Bromidosis	18
Bronchitis, acute	42
Bronchitis, chronic	2
Bronchial cough	34
Bunions	2
Burn	19
Carbuncle	2
Cellulitis	4
Chapped lip	3
Concussion, brain	2
Conjunction, acute	40
Conjunction, purulent	22
Contussion	26
Cyst	2
Cystitis	6
Dermatitis	38
Deviated septum	4
Diarrhea, toxic	8
Dysmenorrhea	3
Dislocation	18
Eczema	6
Epistaxis	3
Epitholioma	1
Erythoma multiforma	1
Examination for health certificates	10
Examination for gymnasium work	32
Flat Feet	6
Foreign Body	26
Fracture	18
Frost bite	3
Furuncle	102
Furunculosis	12
Gastritis	82
Gastro-enteritis	22
Goitre, simple	24
Gun-shot wounds	2
Gun-shot wound, old	3
Hayfever	2
Hematoma	6
Hemorrhoids	4
Herpes simplex	8
Herpes zoster	2
Hordeolum	24
Hydrocele	4

Hyperacidity	6
Hyperchlorhydria	14
Hypertrophied tonsils	40
Hysteria	3
Immunization:	
Anti-Diphtheria	32
Anti-Furunculosis	6
Anti-typhoid	72
Impacted cerumen	24
Indurated ear lobe	1
Infections, local	184
Infective dermatitis	11
Influenza, mild	62
Ingrowing toe nail	4
Lacerations	63
La Grippe	38
Laryngitis, acute	20
Mastoiditis	6
Migraine	42
Mitral disease	12
Mole	2
Myalgia	52
Neuritis	32
Non-healing wound	4
Observation	55
Old fracture	2
Otitis media, acute	14
Otitis media, chronic	2
Ovaritis	2
Pediculosis	12
Phimosis	8
Pharyngitis	318
Physical Examination other than freshmen	70
Poison ivy	10
Post-operative stitch abscess	2
Pleurisy	10
Punctured wound	28
Pruritis ani	2
Psoriasis	2

Quinsy	1
Refer, private physicians	52
Rhinitis, acute	212
Scabies	22
Scoliosis	3
Septic sore throat	92
Shoe pressure	14
Sinusitis, acute	38
Sinusitis, chronic	4
Sprain	48
Strain, ligaments	32
Stomatitis	1
Sunburn	3
Synovitis	2
Tachycardia	12
Tenosynovitis	2
Thyroiditis	2
Tonsillitis	52
Torn ligament	8
Tricophytosis	15
Tuberculosis, incipient	3
Ulcer	2
Variococele	6
Varicose veins	2
Wend	6

LABORATORY

Blood culture	3
Blood count	18
Purulent exudate	13
Smear, throat	132
Stomach analysis	19
Sputum	4
Urine	721
Wasserman	28

A. BORLAND, M. D.,
Director of Health Service.

REPORT OF THE DEAN OF APPLIED SCIENCE.

To the President:—

Sir:—The close of the second year's work for the students in the Applied Science Division has made apparent the wisdom of adding to the course for major subjects, Economics and History and Political Science. Due to popular demand for a more thorough knowledge respecting the underlying fundamental laws which control economic progress for the individual and the nation, a large number of our students have been attracted to the courses in economics which were offered for the first time this year, due mainly to the influence of President David Friday. Some of our students have shown unusual ability and all of them who devoted themselves to Economics have made fair progress. It is perhaps for this reason that the Bregger-Friday prize offered for the best essay on an economic subject was divided between two students, both of them registered in this division. The subject discussed was "Is it to the Economic Advantage of the American Farmer that the Land Values of Farms Should Go Up or Down."

From my viewpoint the outcome of the experiment made when the Applied Science course was established has so far shown conclusively that students of this college in other departments were benefited by the introduction of the course, for during these two years students have entered upon the curriculum offered in the Applied Science Division who had previously had a year or more of work in some one of the technical divisions for which the college has heretofore been famous, namely Agriculture, Engineering, Home Economics and Veterinary Medicine. These students have transferred to this division for various reasons. The most striking one of which is that they have determined for themselves that the technical training in that particular line is not the training which will develop them in the most satisfactory way. On the other hand a number of our students entering last year in this division have determined for themselves that the technical courses offered at M. A. C. were better adapted to their needs than the courses given in the Applied Science division. As a consequence we have had an interchange of students between this division and all other divisions of the college to the decided benefit of the student.

Throughout the year it has been my aim to become fully cognizant with the work of each individual student in the hope that the ideal of good scholarship throughout the course might be cultivated and maintained. Although illness of a rather serious character has prevented me from carrying out the plan to the fullest extent, I still feel that this personal contact with the individual student has proved helpful and that scholarship of the various students has been influenced advantageously by this closer contact.

The number of students registered in the division is somewhat larger than that of last year, the enrollment of last year being 122, and this year, 159. At commencement, three candidates from the Applied Science division were given diplomas, Floyd W. Bueschlen, majoring in Chemistry, Viva L. Davis, majoring in History and Political Science, and Fred W. Henshaw, majoring in Economics.

Owing to the requirements made by the University of Michigan and similar institutions for two years of collegiate training as a prerequisite to entering the medical course, a number of students who may later pursue the course leading to Doctor of Medicine, have found the curriculum of the Applied Science division during the first two years fitted to the premedical requirements. Outlines of the premedical requirements for our students will later appear in the college catalogue.

The committee who prepared the original plan for the Applied Science course, consisting of Dr. Bessey, Professors Ryder and Plant, are still acting with me in the development of the work. Studying the conditions in this institution and others, we are led to believe that the curriculum of study should be broadened, admitting as major subjects both English literature as well as Drawing and Design.

The help of my assistant, Miss Delia Bemis, throughout the year is most gratefully acknowledged.

Respectfully submitted,
FRANK S. KEDZIE,
Dean of Applied Science.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

To the President:—

Sir:—The distribution of class work amongst the teaching staff is indicated by the following tabulations:

SUMMER TERM 1922

Bacteriology 1	28	Ward Giltner
Bacteriology 2	9	F. W. Fabian
Bacteriology 3	4	F. W. Fabian
Bacteriology 1a	1	Ward Giltner
Bacteriology 1c	1	Ward Giltner
Bacteriology 13	2	Ward Giltner
Bacteriology 14	6	Ward Giltner
Bacteriology 23	2	F. W. Fabian
Bacteriology 105	1	H. J. Stafseth

SECOND SUMMER TERM

Bacteriology 1	27	Ward Giltner
Bacteriology 1a	1	Ward Giltner

FALL TERM 1922

Bacteriology 1	49	Ward Giltner
Bacteriology 1a	136	Ward Giltner
Bacteriology 2	15	W. L. Mallmann
Bacteriology 3	9	F. W. Fabian
Bacteriology 4	1	W. L. Mallmann
Bacteriology 4a	9	W. L. Mallmann
Bacteriology 4c	1	Robert L. Tweed
Bacteriology 4n	2	G. L. A. Ruehle
Bacteriology 13	20	Ward Giltner
Bacteriology 23b	1	W. L. Mallmann
Bacteriology 24	3	F. W. Fabian
Bacteriology 25	155	Ward Giltner
Bacteriology 100	1	W. L. Mallmann
Bacteriology 103	1	L. H. Cooledge
Bacteriology 104	1	Robert L. Tweed
Bacteriology 107	2	Robert M. Snyder

WINTER TERM 1922-23

Bacteriology 1a	1	Ward Giltner
Bacteriology 1b	115	Ward Giltner
Bacteriology 2	24	W. L. Mallmann
Bacteriology 2	16	F. W. Fabian
Bacteriology 3	12	F. W. Fabian
Bacteriology 4	3	W. L. Mallman
Bacteriology 4i	4	F. W. Fabian
Bacteriology 4f	6	H. J. Stafseth
Bacteriology 4n	1	G. L. A. Ruehle
Bacteriology 19	1	H. J. Stafseth
Bacteriology 102	1	Robert L. Tweed
Bacteriology 103	1	L. H. Cooledge
Bacteriology 104	1	Robert L. Tweed
Bacteriology 105	1	Robert L. Tweed
Bacteriology 105	3	H. J. Stafseth
Bacteriology 106	1	Robert M. Snyder
Bacteriology 107	1	Robert M. Snyder
Bacteriology 108	3	F. W. Fabian
Short Course	15	Robert M Snyder
Short Course	9	G. L. A. Ruehle

SPRING TERM 1923

Bacteriology 1	85	Ward Giltner
Bacteriology 1c	121	Ward Giltner
Bacteriology 1b	1	Ward Giltner
Bacteriology 2	3	F. W. Fabian
Bacteriology 3	26	F. W. Fabian
Bacteriology 4	1	W. L. Mallmann
Bacteriology 4c	1	F. W. Fabian
Bacteriology 4b	3	W. L. Mallmann
Bacteriology 4d	4	G. L. A. Ruehle
Bacteriology 4j	9	H. J. Stafseth
Bacteriology 4m	1	F. W. Fabian
Bacteriology 4n	1	G. L. A. Ruehle
Bacteriology 14	41	Ward Giltner
Bacteriology 17	1	G. L. A. Ruehle
Bacteriology 19	7	H. J. Stafseth
Bacteriology 23	21	W L. Mallmann
Bacteriology 103	1	L. H. Cooledge
Bacteriology 104	1	F. W. Fabian

Dr. Stafseth has also devoted considerable of his time to a class in poultry husbandry dealing with the prevention and control of poultry diseases. We are considering the desirability of suggesting such a course for another year as a part of the regular work of this department.

There have been no marked changes or incidents of outstanding importance affecting our work.

The special courses for students in the Applied Science Division are being developed in a satisfactory manner. Work with graduate students is progressing in a way that betokens well for the future of the academic standing of the college. We anticipate no trouble as a result of the lowering of required credits but look forward hopefully to a beneficial reaction on scholarship.

Changes already authorized in the organization of the Veterinary Division should strengthen the work of this department. The courses in Parasitology will be listed as Bacteriology 5, 6, 7 and 8 in place of Entomology 8, 14, 16 and 17 respectively. From a practical standpoint this plan should work out advantageously. It is to be hoped that nothing in the operation of the new plan of organization will react unfavorably on any phase of the work in bacteriology.

Robert L. Tweed, Instructor and Research Assistant in Bacteriology, accepted a position with the Gorgas Hospital, Tampico, Mexico, May 1st, 1923. His record with us was very good and his absence has already been felt but it is possible, fortunately to divide up his work and allot different phases of it to the more experienced men in the department. It is felt that this is a better procedure than to attempt to replace Mr. Tweed with an outside man. We are still of the opinon that the best policy is to retain the more experienced men and supply them with plenty of student assistants who will remain as a rule only a relatively few years while in many cases working for an advanced degree. The objections to this plan are obvious and weighty but are overcome by still weightier considerations.

Experience has already reassured us that we may look forward to a new year with promise of much in the way of pleasure and productive results under your leadership.

Respectfully
WARD GILTNER,
Professor of Bacteriology and Hygiene.

REPORT OF THE DEPARTMENT OF BOTANY.

To the President:

Sir:—During the fiscal year just closed the teaching staff of the Botanical Department has maintained its efficiency since, in the main, it has been the same as for several years past. The following changes, however, may be noted:

Assistant Professor Bertha E. Thompson was granted a year's leave of absence, which she has been spending mainly in botanical work in Oregon. Dr. L. A. Kenoyer was appointed in her place for the year. He was, himself, on leave of absence from Ewing Christian College at Allahabad, India It was most fortunate that we were able to substitute for so able a teacher as Miss Thompson a man with such excellent training and experience as Dr. Kenoyer.

Mr. H. C. Young was also granted a year's leave of absence. He accepted a fellowship established by the Plant Protection Institute at the Missouri Botanical Garden, where he received his Ph. D. degree last month. His place was not filled, owing to lack of funds, thus throwing an extra load of work upon Dr. R. P. Hibbard.

The three graduate assistantships were filled by the appointment of Delbert Swartz, a graduate of Miami University, Oxford, Ohio, Dewey Stewart from Alabama Polytechnic Institute, and John R. Cole of Mississippi A. & M. College.

The spirit of scholarship has been excellent the past year, showing a marked improvement upon that of previous years. In part this may have been due to the presence of five graduate students working toward their M. S. degree in Botany, and one with a Ph. D. as his goal, in addition to several graduate students who were taking Botany as a minor subject. One of these graduate students, H. H. Wedgeworth, occupies the National Research Council fellowship established here for the investigation of the relation of sulphur to the control of potato scab.

It is much to be regretted that the shortage of funds made it impossible to purchase some new microscopes, of which the department has been in need for six years. This has also prevented the purchase of some important apparatus for advanced classes in Plant Physiology and Plant Pathology. The Herbarium has suffered most, however, from this shortage of funds, in that is has been impossible to mount and add to the Herbarium many hundred plants that are ready for mounting, besides preventing the purchase of some very important collections of plants which should be added to the Herbarium We have been fortunate in being the recipients of two donations of collections for the Herbarium, one from Dr. D. A. Pelton, M. A. C. '88, now living in Forrest City, Kansas, and the other a very valuable set of Washtenaw County plants from Professor B. A. Walpole, a most enthusiastic amateur botanist, to whom the Department of Botany is continually indebted for assistance in various ways. These collections, however, it has been impossible to mount due to the shortage of funds

The Botanical Garden has been criticized very justly for the lack of labels. This again must be blamed upon the fact that no money was available. In view of the fact that the Botanical Garden and the Herbarium are of great service, it is highly regrettable that they have had to suffer so conspicuously during the past two years.

The botanical interest among the advanced students has been maintained, in part, by the honorary botanical society, the Botanical Seminar. This past year this organization held a Darwin Anniversary Banquet in February, at which Professor H. H. Bartlett of the University of Michigan gave a very interesting address on the subject "Mutation and Evolution." It is expected to make this an annual event.

I wish to record the most loyal co-operation of all members of the botanical staff and employees of the department in this past year. Without such loyalty nothing of value could have been accomplished.

Respectfully submitted,
E. A. BESSEY,
Professor of Botany.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

To the President:—

Sir:—I have the honor to submit the following report on the work of the Department of Chemistry for the year ending June 30, 1923. The teaching staff for the year was as follows:

A. J. Clark, Professor.
R. C. Huston, Associate Professor.
H. S. Reed, Associate Professor.
B. E. Hartsuch, Associate Professor.
D. T. Ewing, Assistant Professor.
H. L. Publow, Assistant Professor.
P. S. Brundage, Assistant Professor.
C. D. Ball, Assistant Professor.
E. F. Eldridge, Instructor.
H. D. Lightbody, Instructor.
W. C. Lewis, Instructor.
R. L. Baxter, Instructor.
H. M. Krebs, Instructor.
M. L. Grettenberger, Assistant.
W. R. Wilson, Graduate Assistant.
Gladys Wardwell, Graduate Assistant.

I feel very well satisfied with the progress made by the Department during the past year. In spite of the crowded condition of the laboratory we have been able to expand the work along our major lines in many ways. Further unification of the work will be effected the coming year by placing Chemistry I for the H. E. Freshmen along with the Chemistry I for the other divisions.

I appreciate fully that much of the success of the past year has been due to the splendid spirit of co-operation which has been shown by every member of the staff, and I take pleasure in acknowledging this at this time.

Fifty-five courses have been offered during the year. The number of students enrolled in the Department during the year was as follows:

Summer Term	1922	93
Fall Term	1922	848
Winter Term	1923	863
Spring Term	1923	664
Total		2,468

Respectfully submitted,
ARTHUR J. CLARK,
Professor of Chemistry.

REPORT OF THE DEPARTMENT OF ECONOMICS

To the President:—

Sir:—The following is the report of the Department of Economics for the academic year 1923-24. The total number of enrollments in the department for the year equalled 2,024—distributed as follows:

By terms: Fall, 727; Winter, 711; Spring, 500; Summer, 86.

By subjects: Economics, 1,858; Sociology, 166.

The total number of hours taught during the year by members of the department equalled 2,574, divided as follows:

By terms: Fall, 836; Winter, 778; Spring, 660; Summer, 300.

By subjects: Economics, 2,394; Sociology, 180.

The adoption of an Engineering Administration course by the college authorities last year has added materially to the subjects given in this department and to the number of teachers. The new subjects were as follows:

Eco. 32, Accounting; Eco. 41, Banking, Securities and Investments; Eco. 42, Transportation; Eco. 43, Bunners Law; Eco. 50, Corporation Finance; Eco. 51, Industrial Relations and Eco. 52, Business Cycles.

The new course was first offered to the juniors of the class of "24" and received an encouraging number of elections. It has also been chosen as the major line of study by a large proportion of the engineering sophomore class so that it bids fair to become a very acceptable sort of work in the engineering division.

The place of economics in the applied science division has also been widely extended. This has arisen through the fact that it is now a major study for applied science students. New economic subjects taught in this division for the first time this year are as follows:

Eco. 3b, Accountancy; Eco. 21, Advanced Economics; Eco. 20, Economic Problems, Eco. 18, Money and Banking; Eco. 19, Railroad Transportation; Eco. 17, Monopolies and Trusts.

During the year the subject of Farm Management has been associated with the department of Economics, instruction in this line of study being given to Juniors in the fall term and to short course and Federal Aid students during the winter term. The extension work which had been carried on for several years in Farm Management was discontinued during this year owing to a lack of suitable help.

Upon the reorganization of the Agricultural Division curriculum, this year, the subject of elementary economics was advanced from the fall term of the freshman year to the spring term of the second year. This was done in order to decrease the time between taking the elements and the election of the specialized courses in Economics as far as possible. Courses known as Eco. 22, Marketing of Specialties; Eco. 23, Market

Research; Eco. 26, Extension Organization and Methods were adopted into this curriculum.

The Home Economics course added a second term of elementary economics to its curriculum and also made the subjects of Eco. 24, Institutional Accountancy; and Eco. 15, Marketing Technique required subjects in the Institutional Management, major.

In the graduate school curriculum, there were added this year Eco. 100, The Economics of Food Production; Eco. 101, Agricultural Economics; Eco. 102, The History of Economic Thought and Eco. 103 Rural Institutions. One student completed the graduate course this year and the number promises to be larger with each succeeding year.

No little encouragement was given to economic study at this place by the offering of a prize by Mr. Louis Bregger "88" and President Friday for the best essay upon the subject "Is it to the economic advantage of the American people that the land values of farms should go up or down." The prize consisted of $100.00 offered by Mr. Bregger and $50.00 offered by President Friday and was striven for by a fairly large number of students. In the end it was divided evenly between Messrs. F. Henshaw "23" and B. Halstead "24" whose essays were considered of even merit by the judges.

In conclusion, commendation for efficient service and generous aid should be given Associate Professors C. S. Dunford, J. T. Horner and J. W. Scott; Assistant Professors R. S. Steiner and Walter Stark, Instructor F. T. Riddell and special lecturers Judge C. B. Collingwood, Mr. Spencer Kelley and Dr. Eben Mumford who have taught one or the other of the various economic subjects during the past year. Commendation too, should be expressed for the help of associate Professor Lloyd Emmons of the Mathematical Department for his able presentation of Eco. 44 "Statistics."

Respectfully submitted,
W. O. HEDRICK,
Professor of Economics Department.

REPORT OF THE DEPARTMENT OF ENGLISH AND MODERN LANGUAGES.

To the President:—

Sir:—I herewith submit for your information a brief report on the work of the Department of English and Modern Languages for the year ending June 30, 1923.

The teaching staff for the year was as follows:

W. W. Johnston, Professor.
E. S. King, Associate Professor.
Mrs. Norma G. Roseboom, Assistant Professor.
R. B. Weaver, Assistant Professor.

L. C. Hughes, Assistant Professor.
O. M. Lebel, Assistant Professor.
A. H. Nelson, Assistant Professor.
L. B. Mayne, Instructor.
J. W. Milne, Instructor.
G. W. Whiting, Instructor.
Oscar Cargill, Instructor.
C. F. Kuhn, Instructor.
C. P. Hotson, Instructor.

Of the above staff, Messrs. King and Milne taught public speaking, Mr. Hughes French, Mr. Lebel Spanish, Mrs. Roseboom English and German. The remaining eight members of the department taught English composition and literature. Mr. Weaver, however, gave but three hours of teaching per week to the department, the rest of his time being taken up by his duties as Director of Student Religious Activities, for the People's Church. This leaves seven persons who gave full time to the teaching of English, and during the winter and spring term Miss Myrtle Maguire who was engaged for English in the Vocational Guidance School, gave us a part of her time. Her doing so enabled me to arrange for repeating, in the winter and the spring term, the freshman courses in composition usually given in the fall and the winter term respectively, thus making it possible for a student who had failed in the fall to repeat the work in the winter and for one who had failed in the winter to repeat the work in the spring.

The number of students enrolled in the department for the year was as follows:

Summer term	1922	130
Fall term	1922	839
Winter term	1923	1064
Spring term	1923	998
Total		3031

During the fall term the students whom we taught in our various courses met in 46 sections, in the winter term in 49 sections, and in the spring term in 52 sections. The number of separate courses given by the department was 51. It would be interesting and perhaps instructive to compare the number of students, courses, sections, and instructors in the department of English and Modern Languages with similar data from other departments.

In addition to its teaching, the department carries on during the year a number of collateral activities. There have been times when, on a Friday or Saturday evening, as many as four or five members of the staff have gone out to judge debates and other contests at various high schools and colleges near to East Lansing. We believe that work of this kind is a service which we owe to the College, and we know that it has a tendency to bring to us men who later become debaters on our own teams. We have also accepted during the year some invitations to deliver addresses away from the College.

Among the collateral activities carried on here at the College by the department are (1) a winter-term play in the Armory and a spring-term play in the Forest of Arden, (2) the Lawson Essay Contest, (3) the Eunomian-Holcad contest, which is for poems and stories, and (4) the training of men and women for our several intercollegiate debates. Since the last three of these are contests, it has been my custom to report the names of students winning honors in them.

The Lawson Essay Contest was won this year by Benjamin V. Halstead, a junior in the course in Applied Science. His essay, entitled "The Offer of the College," will be published in the Commencement number of the M. A. C. Record. It is interesting to note that in 1921 Mr. Halstead contested unsuccessfully for the Lawson prize. Apparently he has in two years developed the ability in analytical thinking and in literary expression which the Lawson contest was instituted to encourage.

First prize in the Eunomian-Holcad contest was awarded to Robert H. Powers for a story entitled "White Bones." Mr. Powers is an Agricultural freshman. This is the second time in the history of this competition that a freshman has won it. It has not been uncommon, however, for a freshman to win one of the several prizes below the first.

Since the men and women (often eminent writers) who are chosen from year to year to judge this contest tell us that it is very difficult to judge justly between such different types of literature as the poem and the short story, and since the offering of a separate first prize for the best poem and of an equal prize for the best short story will greatly encourage contestants, it will be much better if this single contest can be broken into two, with separate judges and prizes. I hope to have this done within a year. I think that I can bring to pass an arrangement by which sufficient funds will be available for supporting both contests in a modest way. If you will consult the Report of the Secretary of the State Board of Agriculture for 1921 (bottom of page 122 to middle of page 123) you will find mention of some of the excellent and definite results which this competition has brought about. The proposed plan should make it possible to get even better results.

Our debate program for 1922-'23 was the most extensive of our history. We took part in many debates and won nearly all of them. One of our teams made a trip through Wisconsin, Illinois, Indiana, Ohio, Massachusetts and Maine, meeting a number of institutions and being beaten but once. Such strong and such various schools as Marquette University, Purdue University, Massachusetts Agricultural College and the University of Maine were among those which our boys defeated. The three debators who made this trip represented three divisions of the college. The men were Douglas V. Steere, Division of Agriculture; Harry G. Smith, Division of Engineering; and Earl H. Chapman, Division of Applied Science.

Separate mention should be made of our winning of the annual Tri-State Debate. A team consisting of Fred M. Johnson, Virgil O. Braun, and Everett Bristol defeated Iowa State College here, and this victory, added to that won over Purdue by our traveling team, gave us the honors of the Tri-State League, which I organized soon after coming to the college.

Mr. Milne organized, this year, debating for women. The students representing us were Dorothy Snyder, Elsie Gelinas, Mrs. Susan

Emshwiller, Marian Harper, Alberta Bates, Marion Stein, Lilian Lewton, and Corlan Lyman. These young women engaged in a dual contest with Western State Normal, in which each institution won one debate.

I wish to renew my recommendation that the personnel and courses in modern languages be organized as a separate department. To what I said in my last report I would add that, since both Professor Hughes and Professor Lebel have been here for a number of years, it seems to me that they deserve the recognition of having their work separately departmentalized. Furthermore the demand for the addition of second-year German, third-year French and second-year Spanish would indicate that the time is near when the full time of three or four persons will be needed to take care of the work in modern languages.

On the whole the year has been an excellent one for the department. The staff has been an able one and the morale excellent. We have been seriously handicapped, and much of our time has been wasted, by the crowding to which we have been subjected in our office and there have been other conditions making our work difficult; but I look forward to a speedy remedy of the most serious of our difficulties and believe that the year of 1923-'24 will be marked by substantial progress.

Respectfully submitted,
W. W. JOHNSTON,
Professor of English and Modern Languages.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY

To the President—

Sir:—Following is a brief report of the Department of Entomology for the year ending June 30, 1923:—

During the year the following changes in personnel have taken place in the department: Mr. S. T. Flynn left during the summer of 1922 and was succeeded in the fall by Mr. C. F. Jolley, Graduate Assistant, who took his major in parasitology under the direction of Dr. Chandler. Mr. Jolley will leave during the present summer. His successor has not yet been appointed. At the beginning of the fall term Mr. J. C. Kremer was appointed Instructor in Apiculture for Vocational students. Dr. Chandler has been transferred to the Department of Bacteriology in the new Veterinary Division, the transfer to take place July 1st.

During the Summer of 1922 the following courses were given:

Entomology I (Introductory).
Entomology II (Fruit Insects).
Entomology F3 (For Federal Vocational Training Students, running twelve weeks).
Entomology 1Xa (Option for seniors in Apiculture).
Also lecturers were given to Agricultural High School teachers.

During the Fall term 1922:—
Entomology III (Field Crops Insects).
Entomology V (Systematic Study of Scale Insects).
Entomology XVIII (Systematic Entomology).
Entomology VIII (Introduction to Parasitology for Veterinarians).
Entomology XIV (Introductory Parasitology—Applied Science).
Entomology 101 (Graduate work).
Entomology IXa (Senior elective in Apiculture).
Entomology Xb (Option in Apiculture).
Entomology F1 (Apiculture for federal vocational training students).
Entomology F4 (Apiculture for federal vocational training students).
During the Winter term 1923:—
Entomology IV (Forest Insects).
Entomology Va-Vb (Systematic Entomology).
Entomology XII (Systematic Entomology).
Entomology XVIIIa (Systematic Entomology).
Entomology Xc (Option in Apiculture).
Entomology F2 (Apiculture for federal vocational training students.
Entomology F5 (Apiculture for federal vocational training students.
Entomology 101 (Graduate work).
Short course for 8 and 16 weeks, second year students. (Entomology for students in general farming.)
Short course (Entomology for students in Horticulture).
Short course (27) (Apiculture for students in Horticulture).
Short course (28) (Two weeks special work on bees).
During the Spring term 1923:—
Entomology Xa (Option in Apiculture for Juniors).
Entomology Xd (Option in Apiculture for Seniors).
Entomology IXb (Electric in Apiculture for Seniors).
Entomology 101 (Graduate work).
Entomology V (Systematic study of scale-insects).
Entomology XVIII (Systematic Entomology).
Entomology I (Introductory).
Entomology II (Fruit Insects).
Entomology F2 (Special course in Apiculture for federal vocational training students).
Entomology F3 (Special course in Apiculture for federal vocational training students).
Entomology F6 (Special course in Apiculture for federal vocational training students).

During the year 103 federal students were given instruction in Apiculture. Besides this, two state training students received the same instruction.

The following schedule gives some idea of the number of students and the distribution of the work:—

Vocational Training Students First Summer Term..	1922	52
Vocational Training Students Second Summer Term.	1922	56
Vocational Training Students Fall term............	1922	80
Vocational Training Students Winter Term........	1923	64
Vocational Training Students Spring Term.........	1923	27

Of these same students

One took five terms.
Twenty-four took four terms.
Thirty-three took three terms.
Thirty-four took two terms.
Twelve took one term.

Several out-apiaries belonging to the students were maintained in order to give vocational training students facilities for handling bees.

Owing to the transfer of the work in Parasitology to the Department of Bacteriology, Courses in what are now listed as Entomology VIII, XIV, XVI, and XVII in the future will be given in that department.

In January 1923, a twenty-four page outline of a course to be used in teaching Apiculture in Michigan high schools was published jointly by the Department of Entomology and the Teacher-Training Department. This outline has been received very favorably both in our state and in other states. The edition was exhausted almost as soon as printed and it will be necessary to reprint it as soon as funds are available.

Respectfully submitted,
R. H. PETTIT,
Professor of Entomology.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

To the President:—

Sir:—I have the honor to submit for your consideration the following report on the work of the Department of Mathematics for the year ending June 30, 1923.

During the year the teaching staff of the Department was as follows:

L. C. Plant, Professor.

L. C. Emmons, G. G. Speaker, S. E. Crowe, Associate Professors.

V. G. Grove, Assistant Professor.

R. C. Huffer, J. E. Robertson, R. N. Haskell, J. M. Earl, Instructors.

At the close of the year Dr. F. E. Wood resigned to accept a professorship in Northwestern University. In his resignation the College suffered a great loss. Mr. S. J. Daley resigned to go into business.

New appointees for the year were Mr. R. N. Haskell of the University of Chicago and Mr. J. M. Earl of the University of Minnesota.

The total number of students taking mathematics during the year was 1790, divided among the different terms as follows: fall, 570, winter, 552, spring, 546, summer, 122. The total number of class periods for the year was 440, divided among the different terms as follows: fall, 145, winter, 130, spring, 115, summer, 50.

Respectfully submitted,
L. C. PLANT,
Professor of Mathematics.

REPORT OF THE DEPARTMENTH OF MILITARY SCIENCE.

To the President:—

Sir:—The following is a brief report of the Department of Military Science and Tactics for the year ending June 30, 1923.

I. INSTRUCTION.

The Department has made rapid. progress during the past year Inspectors from the War Department stated that the system and methods of instruction here were the equal if not the superior of any college in the country. We were surpassed however, by many colleges in the facilities available, in the percentage of basic students taking advanced training and in the arrangement of proper hours for the juniors and seniors.

Things have changed from the "old days" when the idea of Military Training was merely "squads right" and physical training could be substituted for it. Now two thirds of all instruction is class room work from text books. Students are required to prepare lessons and recite as in any other department. The practical or outdoor work is in the nature of laboratory work. A student who completes the Four years R. O. T. C. course is qualified for a commission in the Officer's Reserve Corps, and ready to assume the duties of a lieutenant in time of war.

The following is a partial list of the subjects covered during the four years: Drill regulations, Courtesy, Map Reading and map making, weapons of all kinds and arms, military hygiene, field engineering, military law, military history, tactics, administration, equitation, selection and care of animals, artillery material, orientation, motor transportation and gunnery.

The Freshmen and Sophomores spend three (3) hours per week and the juniors and seniors five (5) hours per week on military training.

II. ENROLLMENT.

The average attendance, by classes, for the year was as follows:

Seniors	42
Juniors	59
Sophomores	192
Freshmen	295
Total	448

III. TEACHING STAFF.

The personnel of the Department has been as follows:

Lieut. Colonel T. L. Sherburne, Cavalry, U. S. Army.

Captain J. J. Teter, C. A. C. U. S. Army.
Captain W. C. Chase, Cavalry, U. S. Army.
Captain L. B. Wyant, Cavalry, U. S. Army.
Captain H. B. Beavers, Infantry, U. S. Army.
Captain W. H. Warren, C. A. C. U. S. Army.
Sergeants J. Foley, J. Meskill, C. P. Riley, J. H. Atchison, and B. E. Workman, all D. E. M. L. U. S. Army.
14 Privates, of the D. E. M. L. U. S. Army.

The Officers and Sergeants were instructors and the privates cared for the horses and equipment.

The instructors have given excellent service, but they are at considerable more expense here than they would be at an army post. At an army post they would be furnished quarters, heat, light, water, medical and dental attention by the government in addition to their salary. When on duty such as this they are given an additional allowance but it hardly covers the cost of renting a house in East Lansing. In every case the heat, light, water, etc. must be paid out of their salary, which is a loss. These people are sent here by the War Department and must stay whether they like it or not so it is hardly fair that they should suffer a monetary loss, and in many cases run behind because they are good enough to be selected for this superior duty. An effort should be made to pay these people an amount, at least, equal to what they lose by being on duty here, as nearly every college in the country does.

IV. EQUIPMENT.

The equipment furnished by the War Department is quite complete, except the number of horses. There are now 40 horses on hand and fifteen more have been promised. The total value of the equipment furnished the college by the War Department is more than $140,000.

Most of the equipment furnished by the college has become obsolete or worn out. Very little has been purchased during the past two or three years through lack of funds.

An outdoor rifle and pistol range should be constructed at once.

V. UNIFORMS.

The uniforms were in the main very satisfactory and furnished by the government at no cost to the college or the students. Each junior and senior was given a tailor made uniform which became his own property after he used it one year. Each freshman and sophomore was issued a Regular Army uniform for use while at college, but it had to be returned at the end of the year. The students kept the uniforms up very well and presented a very creditable appearance.

VI. BUILDINGS, GARAGE, STABLES.

The armory is inadequate, and an effort should be made to obtain a suitable building. Classes had to be held in the offices, garage, basement and gymnasium and in some cases two classes were conducted in one room.

The cavalry stables are too far away and cavalry instruction proper cannot be given during about half of the year because of the weather; a riding hall is absolutely necessary.

The floor space, lighting and heating furnished the artillery unit during the past year was as good as any, but the present building is to be, and should be torn down. Another will have to be provided at once to house the equipment and give class room space by next fall.

VII. THE BUDGET.

During the past year the college spent about $3,630.00 on the upkeep of the Military Department for salary for Janitor and Armorer, repairs to building and minor equipment and for the band; $665.00 was spent on the band. During the same period the War Department spent $67,270.54 for salaries for personnel, feed and upkeep of horses and repairs and upkeep of equipment and uniforms for the students.

The college budget was inadequate. A stenographer's salary should be included in next year's budget as one is badly needed.

VIII. ACTIVITIES.

A. Rifle Club. Membership in the club was about 400, including men and women students. Cups were awarded to winning teams and medals to team members and high score winners. The girls classes did especially good work. Rifle matches were held with other colleges, winning the majority of the matches.

B. Sponsors were elected this year as usual.

C. The Rotary and Kiwanis held a rifle shoot under the supervision of the Military Department in the Armory.

D. A Military Ball was held in the gymnasium during the winter term under the supervision of the Cadet Officer's Club. Every one was required to wear a uniform except guests of the officers club. The demand for tickets was so great that they had to be limited to 175.

E. A field meet was held at the close of the spring term. Contests, partly military and partly athletic in character, of a nature that would be equal for all units. Interest ran high.

F. Every Monday afternoon at 4:00 p. m. a parade or review was held for some distinguished person or organization. Parades or reviews were held for: The National Guard Officers, General Hale, Commanding 6th Corps Area, Business men's clubs of Lansing, Federation of women's clubs, the Corps Sponsors and for the seniors who graduated in the R. O. T. C. Large crowds attended all parades.

G. A Polo Association was formed by the cadet officers; Cavalry horses are used. This organization will attract much attention in the future.

H. A Horse Show was held on the college grounds May 30; it was a success from every point of view. The proceeds went to the band and Polo Association. Plans are being made to hold one every year.

IX. RECOMMENDATIONS.

It is recommended that a small amount of the thousands of dollars received from the Federal Government by reason of the fact that this is a land grant college and giving military training, be spent on the military department so that this department can function with the same efficiency as the military departments of other colleges and other departments of the college.

Respectfully submitted,
T. L. SHERBURNE,
Lieutenant Colonel, Cavalry, D. O. L.
Professor of Military Science and Tactics.

REPORT OF THE DEPARTMENT OF METEOROLOGY.

To the President:—

Sir:—Following is a report of the Department of Meteorology for the year ending June 30, 1923:

The usual course in meteorology, as an elective for junior and senior agricultural students, was conducted during the spring term. Twelve students enrolled for this work.

It is believed that meteorology should be a required subject for students in agriculture, especially for those specializing in horticulture. The weather is one of the most vital factors in fruit growing, not to mention its importance in general farming.

Respectfully submitted,
D. A. SEELEY,
Instructor in Meteorology.

METEOROLOGICAL TABLES

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, JULY, 1922.

Date.	Temperature.			Precipitation in inches.	Character of day	Percentage of possible sunshine
	Highest	Lowest	Mean			
1	86	68	77	0	Partly Cloudy	72
2	84	64	74	0	Partly Cloudy	90
3	70	51	60	0	Partly Cloudy	97
4	72	44	58	0	Clear	100
5	78	46	62	0	Clear	100
6	85	56	70	0	Partly Cloudy	74
7	79	57	68	0.01	Cloudy	45
8	80	55	68	0	Partly Cloudy	55
9	87	57	72	0	Partly Cloudy	88
10	90	68	79	0.84	Cloudy	57
11	80	66	73	0.74	Cloudy	29
12	82	59	70	0.32	Cloudy	38
13	79	56	68	0	Clear	80
14	82	52	67	0	Clear	100
15	83	55	69	0	Clear	100
16	88	60	74	0.37	Cloudy	40
17	82	62	72	0.02	Cloudy	41
18	77	58	68	0	Partly Cloudy	89
19	78	54	66	0	Clear	97
20	81	53	67	0	Clear	97
21	83	57	70	0	Partly Cloudy	75
22	85	63	74	0.03	Partly Cloudy	28
23	85	67	76	0	Partly Cloudy	54
24	80	55	68	0	Cloudy	68
25	82	51	66	0	Clear	91
26	82	62	72	0	Partly Cloudy	41
27	86	63	74	0	Partly Cloudy	63
28	85	60	72	0	Partly Cloudy	79
29	82	56	69	0	Cloudy	94
30	83	56	70	T.	Partly Cloudy	82
31	83	61	72	0.24	Cloudy	43

Mean highest tenperature	81.9°
Mean lowest temperature	57.8°
Mean temperature for month	69.8°
Total precipitation for month	2.57

WEATHER

Number days clear	8
Partly cloudy	14
Cloudy	9
With 0.01 inch or more of precipitation	8

SUNSHINE

Number hours sunshine	331.4
Possible hours sunshine	464.9
Percentage of possible	71

This month since 1863		
Year.	Mean temperature.	Total precipitation.
1863		
1864	74.5	1.25
1865	65.6	3.91
1866	71.7	4.19
1867	71.6	1.78
1868	77.2	1.11
1869	70.4	5.77
1870	74.4	8.02
1871	70.6	3.10
1872	74.9	3.36
1873	70.8	5.12
1874	72.0	2.56
1875	69.7	2.42
1876	72.5	2.10
1877	71.4	2.25
1878	73.0	2.96
1879	74.0	2.19
1880	68.0	6.27
1881	73.1	1.81
1882	67.5	2.32
1883	68.9	1.27
1884	68.0	12.60
1885	72.7	2.52
1886	70.7	0.65
1887	75.5	1.50
1888	70.5	2.40
1889	70.2	3.41
1890	71.1	0.92
1891	65.3	1.88
1892	70.3	2.00
1893	71.5	1.86
1894	73.2	0.86
1895	70.5	1.47
1896	71.8	6.73
1897	73.8	8.49
1898	70.0	1.34
1899	69.8	2.11
1900	69.6	4.15
1901	74.2	5.08
1902	70.6	7.13
1903	67.9	3.79
1904	69.2	1.97
1905	69.8	5.75
1906	70.8	2.23
1907	70.0	4.30
1908	73.2	1.03
1909	70.0	2.56
1910	71.0	1.53
1911	71.3	1.65
1912	69.6	5.06
1913	70.8	2.85
1914	71.0	1.65
1915	67.9	5.17
1916	76.1	0.09
1917	70.0	3.06
1918	69.2	1.96
1919	72.4	1.69
1920	67.3	3.01
1921	77.0	2.61
1922	69.8	2.57
Normal	70.9	3.22

BAROMETER—Mean, 30.00 inches; highest, 30.34 inches, on 13th; lowest, 29.62 inches, on 7th.

TEMPERATURE—Highest, 90° on 10th; lowest, 44°, on 4th; greatest daily range, 32° on 5th; least daily range, 14°, on 11th; normal temperature, 70.9°; departure, —1.1°; accumulated departure since January 1, +354°; average daily departure since January 1, +1.7°; highest in 37 years, 102°; lowest, 37°.

PRECIPITATION (in inches)—Total this month, 2.57; normal, 3.22; departure —0.65; since January 1, —1.68; greatest amount in 24 hours, 1.58, on 10th and 11th; total snowfall, 0.0 in.

WIND—Prevailing direction, northwest; total movement, 3,258 miles; average hourly velocity, 4.4 miles. maximum velocity. 22 miles per hour from southwest on 12th.

DATES OF—Auroras, 28–29; hail, 0; sleet, 0; fog, dense, 12; thunderstorms, 10, 11, 16, 17, 22, 31; halos, solar, 2, 6, 9, 29.; halos, lunar, 0; frost, killing, 0; heavy, 0; light, 4.

B. B. WHITTIER, Meteorologist,
Temporarily in charge.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, AUGUST, 1922.

Date	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	80	61	70	0.26	Partly Cloudy	51
2	84	60	72	0.01	Partly Cloudy	68
3	81	58	70	0.88	Partly Cloudy	65
4	79	58	68	0	Partly Cloudy	53
5	82	54	68	0.02	Partly Cloudy	69
6	78	60	69	0.08	Cloudy	23
7	85	59	72	0.04	Partly Cloudy	56
8	72	49	60	0	Partly Cloudy	72
9	74	44	59	0	Clear	96
10	80	50	65	0	Clear	92
11	82	54	68	0	Partly Cloudy	77
12	85	56	70	0	Partly Cloudy	69
13	88	61	74	0	Clear	96
14	91	60	76	0	Clear	100
15	92	58	75	0	Clear	91
16	94	62	78	0	Clear	85
17	94	64	79	T.	Partly Cloudy	94
18	88	64	76	0	Partly Cloudy	89
19	78	54	66	0	Partly Cloudy	88
20	77	53	65	0	Clear	99
21	71	50	60	T.	Cloudy	20
22	85	62	74	0.10	Cloudy	30
23	79	69	74	0.05	Cloudy	7
24	83	63	73	0.26	Partly Cloudy	46
25	76	52	64	0.09	Partly Cloudy	71
26	73	49	61	0	Partly Cloudy	65
27	76	50	63	0	Partly Cloudy	81
28	80	51	66	T.	Partly Cloudy	87
29	75	56	66	0.63	Partly Cloudy	36
30	78	52	65	0	Clear	98
31	81	53	67	0	Clear	98

Mean highest temperature	81.3°
Mean lowest temperature	56.3°
Mean temperature for month	68.8°
Total precipitation for month	2.42

Weather

Number days clear	9
Partly cloudy	18
Cloudy	4
With 0.01 inch or more of precipitation	11

Sunshine

Number hours sunshine	302.1
Possible hours sunshine	430.7
Percentage of possible	70

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863	....	3.00
1864	70.7	0.39
1865	65.8	3.38
1866	62.6	3.44
1867	69.8	1.74
1868	70.3	2.42
1869	70.6	4.85
1870	70.1	4.53
1871	71.2	1.42
1872	71.2	4.18
1873	69.5	0.80
1874	69.4	1.28
1875	65.5	1.47
1876	71.6	1.28
1877	68.5	6.57
1878	70.2	1.85
1879	70.0	1.61
1880	68.6	6.02
1881	72.7	1.63
1882	69.5	5.72
1883	64.9	0.18
1884	66.9	1.30
1885	63.6	6.75
1886	69.3	4.69
1887	68.0	0.89
1888	67.6	1.87
1889	68.6	0.68
1890	65.4	3.60
1891	67.9	4.82
1892	68.3	5.12
1893	68.1	0.56
1894	68.8	0.00
1895	71.2	4.64
1896	70.0	4.73
1897	65.9	1.69
1898	69.0	2.73
1899	71.4	0.70
1900	73.3	2.98
1901	68.4	2.49
1902	64.2	0.68
1903	64.3	6.73
1904	65.9	3.26
1905	69.6	3.92
1906	73.5	4.35
1907	65.5	2.87
1908	68.4	3.99
1909	71.0	1.61
1910	68.2	1.76
1911	68.2	1.48
1912	65.7	2.19
1913	69.4	5.60
1914	68.9	3.33
1915	63.4	4.63
1916	71.0	1.58
1917	67.0	1.47
1918	72.2	1.44
1919	67.3	4.03
1920	67.9	2.00
1921	68.6	5.18
1922	68.8	2.42
Normal	68.4	2.63

Barometer—Mean, 30.00 inches; highest, 30.27 inches, on 14th; lowest, 29.52 inches, on 25th.

Temperature—Highest, 94°, on 16th; lowest, 44° ,on 9th; greatest daily range, 34°, on 15th; least daily range, 10°, on 23rd; normal temperature, 68.4°; departure, +0.4°; accumulated departure since January 1, +368°; average daily departure since January 1, +1.5°; highest in 37 years, 102°; lowest, 32°.

Precipitation (in inches)—Total this month, 2.42; normal, 2.63; departure, —0.21; since January 1st, —1.89; greatest amount in 24 hours, 0.88, on 3rd; total snowfall, 0.0 in.

Wind—Prevailing direction, northwest; total movement, 2,630 miles; average hourly velocity, 3.5 miles; maximum velocity, 19 miles per hour from north, on 3rd.

Dates of—Auroras, 0; hail, 3; sleet, 0; fog, dense, 1; Thunderstorms, 1, 2, 3, 5, 6, 7, 16, 17, 22, 24, 25, 29; halos, solar, 21, 24; halos, lunar, 0; frost, killing, 0; heavy, 0; light, 4.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, SEPTEMBER, 1922

Date.	Temperature.			Precipitation in inches.	Character of day	Percentage of possible sunshine
	Highest	Lowest	Mean			
1	84	58	71	0.52	Cloudy	23
2	89	69	79	0	Partly Cloudy	60
3	85	65	75	T.	Partly Cloudy	47
4	86	60	73	0	Clear	97
5	91	63	77	0	Clear	100
6	93	68	80	T.	Partly Cloudy	92
7	88	68	78	0.17	Cloudy	33
8	94	67	80	0	Clear	100
9	83	68	76	0.06	Cloudy	31
10	73	55	64	0.51	Cloudy	4
11	69	50	60	0.26	Partly Cloudy	56
12	70	47	58	0	Partly Cloudy	56
13	67	52	60	0.47	Cloudy	21
14	62	52	57	0.90	Cloudy	2
15	72	52	62	0	Partly Cloudy	66
16	65	43	54	0	Partly Cloudy	79
17	65	38	52	0	Partly Cloudy	69
18	65	40	52	0.03	Cloudy	27
19	64	52	58	0.01	Cloudy	5
20	72	51	62	0	Partly Cloudy	65
21	76	45	60	0	Clear	100
22	81	51	66	0	Clear	100
23	83	54	68	0	Clear	100
24	67	42	54	0	Clear	94
25	66	36	51	0	Clear	88
26	68	37	52	0	Clear	100
27	74	38	56	0	Clear	100
28	80	43	62	0	Clear	100
29	84	43	64	0	Clear	100
30	85	51	68	0	Clear	100
31	....	....	....	....	....	....

Mean highest temperature........ 76.7°
Mean lowest temperature........ 51.9°
Mean temperature for month........ 64.3°
Total precipitation for month........ 2.93°

Weather

Number days clear........ 13
Partly cloudy........ 9
Cloudy........ 8
With 0.01 inch or more of precipitation........ 9

Sunshine

Number hours sunshine........ 249.9
Possible hours sunshine........ 374.8
Percentage of possible........ 67

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863	....	0.89
1864	59.6	3.53
1865	67.7	4.79
1866	55.8	5.80
1867	56.6	1.42
1868	58.8	2.95
1869	63.5	1.43
1870	63.7	2.85
1871	59.1	0.79
1872	62.0	5.21
1873	67.4	3.50
1874	62.8	1.27
1875	58.5	2.89
1876	56.3	3.65
1877	61.3	1.38
1878	63.2	3.41
1879	56.2	3.19
1880	55.8	3.10
1881	69.7	2.91
1882	59.9	0.67
1883	56.4	2.34
1884	65.1	3.34
1885	58.9	3.75
1886	62.1	5.40
1887	58.9	4.72
1888	57.8	1.89
1889	61.2	0.79
1890	57.7	1.67
1891	65.1	1.10
1892	60.8	2.17
1893	58.4	1.84
1894	63.7	2.59
1895	66.6	0.85
1896	57.6	6.73
1897	62.9	0.80
1898	63.3	3.00
1899	57.0	2.14
1900	63.2	0.89
1901	61.7	1.67
1902	58.7	5.88
1903	61.0	2.86
1904	62.0	2.35
1905	63.8	3.21
1906	67.5	0.76
1907	61.8	4.68
1908	66.4	0.65
1909	60.4	1.51
1910	60.2	2.74
1911	61.5	5.05
1912	62.7	3.33
1913	61.0	1.53
1914	60.3	2.65
1915	63.2	6.55
1916	60.4	2.17
1917	58.6	4.60
1918	54.2	2.88
1919	63.8	2.61
1920	64.2	1.62
1921	66.6	2.64
1922	64.3	2.93
Normal	61.6	2.62

Barometer—Mean, 30.12 inches, highest, 30.47 inches, on 17th; lowest, 29.81 inches, on 2nd.

Temperature—Highest, 94°, on 8th; lowest, 36°, on 25th; greatest daily range, 41°, on 29th; least daily range, 10°, on 14th; normal temperature, 6.16°; departure, +2.7°; accumulated departure since January 1, +449°; average daily departure since January 1, +1.7°; highest in 37 years, 99°; lowest, 21°.

Precipitation (in inches)—Total this month, 2.93; normal, 2.62; departure, +0.31; since January 1, —1.58; greatest amount in 24 hours, 1.37, on 13th and 14th; total snowfall, 0.0 in.

Wind—Prevailing direction, southwest; total movement, 2,462 miles; average hourly velocity, 3.4 miles; maximum velocity, 14 miles per hour from northwest on 24th.

Dates of—Auroras, 16; hail, 0; sleet, 0; fog, dense, 14; thunderstorms, 1, 6, 7, 9, 10; halos, solar, 17; halos, lunar, 0; frost, killing, 0; heavy, 25, 26; light, 27.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, OCTOBER, 1922

Date	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	68	54	61	0.07	Cloudy	21
2	86	59	72	0	Clear	100
3	85	55	70	0	Partly Cloudy	88
4	85	55	70	0	Partly Cloudy	81
5	87	60	74	0	Partly Cloudy	84
6	70	55	62	0.01	Partly Cloudy	37
7	60	48	54	1.37	Cloudy	0
8	49	43	46	T.	Cloudy	0
9	61	43	52	0	Cloudy	19
10	57	48	52	0.45	Cloudy	0
11	60	39	50	0.09	Cloudy	21
12	46	28	37	T.	Cloudy	18
13	55	28	42	0	Partly Cloudy	79
14	69	45	57	0.16	Partly Cloudy	78
15	60	45	52	0.10	Cloudy	15
16	65	45	55	0	Partly Cloudy	57
17	47	39	43	T.	Cloudy	4
18	49	29	39	0	Clear	79
19	61	27	44	0	Clear	99
20	54	25	40	0	Clear	100
21	69	34	52	0	Clear	100
22	70	43	56	0.04	Partly Cloudy	78
23	50	37	44	0.19	Cloudy	13
24	58	33	46	0	Cloudy	16
25	60	36	48	0	Partly Cloudy	58
26	46	34	40	0	Partly Cloudy	45
27	66	34	50	0	Clear	92
28	57	39	48	0	Partly Cloudy	79
29	70	38	54	0	Clear	100
30	60	35	48	0	Clear	100
31	60	35	48	0	Partly Cloudy	66

Mean highest temperature	62.6°
Mean lowest temperature	40.9°
Mean temperature for month	51.8°
Total precipitation for month	2.48

WEATHER

Number days clear	8
Partly cloudy	12
Cloudy	11
With 0.01 inch or more of precipitation	9

SUNSHINE

Number hours sunshine	189.5
Possible hours sunshine	341.9
Percentage of possible	55

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863	....	1.04
1864	45.7	1.86
1865	46.5	2.76
1866	49.5	3.57
1867	50.6	2.11
1868	45.2	1.11
1869	40.8	1.72
1870	52.5	2.29
1871	53.9	1.43
1872	47.4	0.67
1873	44.7	1.91
1874	49.1	0.49
1875	42.9	5.81
1876	43.7	1.26
1877	50.8	5.69
1878	48.3	1.99
1879	57.3	1.57
1880	46.2	2.84
1881	52.5	5.56
1882	52.7	2.64
1883	46.2	3.66
1884	50.9	5.73
1885	45.0	3.08
1886	52.4	0.95
1887	45.0	1.86
1888	45.7	3.00
1889	44.2	0.65
1890	49.1	4.56
1891	48.8	0.82
1892	48.3	0.78
1893	49.7	3.61
1894	49.8	1.91
1895	45.0	1.41
1896	44.6	1.06
1897	53.1	2.15
1898	49.6	3.55
1899	53.2	2.68
1900	56.6	2.77
1901	49.6	4.61
1902	49.6	1.53
1903	51.0	2.01
1904	48.6	1.90
1905	50.9	1.75
1906	49.2	2.36
1907	46.0	2.22
1908	51.6	0.82
1909	46.2	0.71
1910	51.8	2.27
1911	48.0	5.00
1912	50.4	3.44
1913	50.2	3.30
1914	54.6	2.81
1915	51.1	0.70
1916	49.7	2.53
1917	41.2	3.44
1918	52.6	3.21
1919	53.3	2.90
1920	57.8	1.37
1921	50.5	2.85
1922	51.8	2.48
Normal	49.0	2.23

BAROMETER—Mean, 30.01 inches; highest, 30.41 inches, on 13th; lowest, 29.56 inches, on 11th.

TEMPERATURE—Highest, 87°, on 5th; lowest, 25°, on 20th; greatest daily range, 35°, on 21st; least daily range, 6° on 8th; normal temperature, 49.0°; departure, +2.8°; accumulated departure since January 1, +535°; average daily departure since January 1, +1.8°; highest in 37 years, 90°; lowest, 10°.

PRECIPITATION (in inches)—Total this month, 2.48; normal, 2.23; departure, +0.25; since January 1, —1.33; greatest amount in 24 hours, 1.38, on 6th and 7th; total snowfall, T. in.

WIND—Prevailing direction, southwest; total movement, 3,827 miles; average hourly velocity, 5.1 miles; maximum velocity, 23 miles per hour, from northwest on 23rd.

DATES OF—Auroras, 0; hail, 0; sleet, 0; fog, dense, 31; thunderstorms, 1; halos, solar, 3, 5, 13, 22, 24, 25, 29, 31; halos, lunar, 3, 28, 31: frost, killing, 13.; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, NOVEMBER, 1922

Date.	Temperature.			Precipitation in inches.	Character of day	Percentage of possible sunshine
	Highest	Lowest	Mean			
1	60	36	48	0.14	Cloudy	38
2	55	50	52	0.54	Cloudy	0
3	57	51	54	0	Cloudy	0
4	55	46	50	0	Cloudy	0
5	62	42	52	0.17	Cloudy	67
6	59	47	53	0	Partly Cloudy	73
7	51	39	45	T.	Partly Cloudy	52
8	49	38	44	0.08	Cloudy	23
9	45	30	38	0	Partly Cloudy	48
10	53	28	40	0	Partly Cloudy	70
11	58	43	50	0.01	Cloudy	2
12	51	37	44	0.22	Cloudy	0
13	48	37	42	0.05	Cloudy	2
14	56	38	47	0.13	Cloudy	0
15	40	33	36	0	Cloudy	0
16	49	32	40	0	Clear	96
17	53	35	44	0.03	Partly Cloudy	93
18	49	40	44	0.10	Cloudy	5
19	48	36	42	0.02	Cloudy	5
20	37	31	34	0.02	Cloudy	0
21	36	25	30	0.11	Cloudy	5
22	35	29	32	T.	Cloudy	0
23	50	33	42	0	Partly Cloudy	72
24	34	24	29	T.	Cloudy	23
25	29	24	26	T.	Cloudy	0
26	30	24	27	0.15	Cloudy	1
27	35	22	28	0.01	Cloudy	12
28	32	21	26	0	Cloudy	31
29	42	25	34	0	Clear	90
30	56	32	44	0.01	Cloudy	0
31						

Mean highest temperature	47.1°
Mean lowest temperature	34.3°
Mean temperature for month	40.7°
Total precipitation for month	1.79

WEATHER

Number days clear	2
Partly cloudy	6
Cloudy	22
With 0.01 inch or more of precipitation	16

SUNSHINE

Number hours sunshine	79.0
Possible hours sunshine	292.1
Percentage of possible	27

This month since 1863		
Year.	Mean temperature.	Total precipitation.
1863	....	0.40
1864	37.9	4.12
1865	38.6	0.68
1866	37.9	2.60
1867	40.4	1.77
1868	36.8	2.44
1869	32.1	1.93
1870	38.4	0.91
1871	32.0	1.25
1872	29.8	0.98
1873	28.5	2.03
1874	35.0	1.61
1875	33.0	1.11
1876	36.3	0.91
1877	35.2	3.67
1878	36.3	2.16
1879	38.2	4.55
1880	27.5	2.32
1881	38.2	4.09
1882	36.3	1.83
1883	38.1	3.98
1884	34.1	1.84
1885	37.2	2.90
1886	33.9	1.48
1887	35.7	2.28
1888	38.5	3.12
1889	37.4	2.67
1890	39.1	2.30
1891	34.0	3.34
1892	34.2	1.84
1893	35.6	2.19
1894	32.5	0.97
1895	35.4	3.87
1896	37.1	1.05
1897	36.5	2.94
1898	33.1	2.72
1899	39.7	1.72
1900	35.3	5.10
1901	32.8	1.21
1902	43.0	2.46
1903	34.0	1.45
1904	40.0	0.04
1905	35.8	2.25
1906	37.0	2.66
1907	36.0	1.83
1908	38.2	1.82
1909	44.5	3.74
1910	34.0	1.37
1911	33.8	3.40
1912	38.6	2.86
1913	41.7	2.38
1914	37.6	1.40
1915	39.8	2.23
1916	38.8	1.68
1917	35.8	0.82
1918	40.4	3.22
1919	35.7	2.44
1920	36.6	2.29
1921	35.2	4.06
1922	40.7	1.79
Normal	36.8	2.41

BAROMETER—Mean, 30.07 inches; highest, 30.49 inches, on 12th; lowest, 29.52 inches, on 27th.

TEMPERATURE—Highest, 62°, on 5th; lowest, 21°, on 23th; greatest daily range, 25° on 10th; least daily range, 5°, on 25th; normal temperature, 36.8°; departure, +3.9°; accumulated departure since January 1, +648°; average daily departure since January 1, +1.9°; highest in 37 years, 72°; lowest, 0°.

PRECIPITATION (in inches)—Total this month, 1.79; normal, 2.41; departure, —0.62; since January 1, —1.95; greatest amount in 24 hours, 0.67, on 1st and 2nd; total snowfall, 3.5 in.

WIND—Prevailing direction, southwest; total movement, 5,273 miles; average hourly velocity, 7.3 miles; maximum velocity, 23 miles per hour, from northwest on 23rd.

DATES OF—Auroras, 0; hail, 0; sleet, 0; fog, dense, 0; Thunderstorms, 5; halos, solar, 1, 5; halos, lunar, 10; frost, killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, DECEMBER, 1922

Date	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	57	25	41	0.16	Clear	97
2	42	22	32	0.16	Clear	87
3	50	28	39	0	Clear	100
4	41	26	34	0.29	Cloudy	0
5	39	18	28	T.	Partly Cloudy	74
6	26	14	20	0	Cloudy	10
7	36	25	30	0.01	Cloudy	0
8	51	17	34	0.17	Cloudy	20
9	27	14	20	T.	Partly Cloudy	84
10	34	11	22	0	Clear	100
11	40	25	32	0	Cloudy	0
12	36	9	22	0.02	Cloudy	25
13	20	10	15	0.10	Cloudy	8
14	21	16	18	0.17	Cloudy	21
15	21	4	12	T.	Cloudy	22
16	27	2	14	0	Partly Cloudy	76
17	27	7	17	0.02	Cloudy	22
18	11	2	6	T.	Partly Cloudy	44
19	19	6	12	T.	Cloudy	24
20	35	19	27	T.	Cloudy	34
21	29	23	26	0	Cloudy	23
22	38	26	32	0.01	Partly Cloudy	42
23	36	29	32	T.	Cloudy	3
24	34	31	32	T.	Cloudy	0
25	37	31	34	0	Cloudy	20
26	42	27	34	0	Partly Cloudy	61
27	32	25	28	0	Cloudy	0
28	29	20	24	T.	Cloudy	0
29	27	14	20	T.	Cloudy	4
30	37	23	30	0	Cloudy	11
31	41	30	36	0.08	Cloudy	0

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863	....	1.71
1864	24.4	3.20
1865	26.7	1.43
1866	25.5	1.90
1867	25.3	1.34
1868	21.2	1.35
1869	28.2	2.11
1870	24.8	2.57
1871	21.1	1.76
1872	15.7	1.06
1873	29.5	3.02
1874	27.0	0.37
1875	31.6	2.80
1876	15.2	1.29
1877	36.6	1.03
1878	21.3	2.27
1879	27.5	3.55
1880	22.1	0.85
1881	34.3	1.75
1882	24.8	0.88
1883	26.4	1.28
1884	24.7	4.15
1885	27.8	2.14
1886	19.7	1.56
1887	27.3	3.32
1888	30.4	1.20
1889	36.8	2.61
1890	26.4	1.12
1891	34.6	1.47
1892	25.6	1.52
1893	27.6	2.28
1894	30.1	0.93
1895	28.5	5.39
1896	28.1	0.80
1897	25.6	2.02
1898	24.8	1.42
1899	25.0	1.51
1900	26.7	0.50
1901	21.6	3.00
1902	24.8	2.89
1903	19.7	1.75
1904	21.7	1.42
1905	30.2	2.54
1906	26.8	1.85
1907	22.7	4.19
1908	26.4	2.08
1909	23.0	2.91
1910	21.6	1.28
1911	31.1	1.58
1912	31.0	1.20
1913	31.8	0.55
1914	21.6	1.57
1915	24.8	1.01
1916	22.7	2.11
1917	19.1	0.74
1918	32.9	3.61
1919	19.4	0.86
1920	30.6	3.94
1921	28.4	3.54
1922	26.2	1.03
Normal	26.8	2.08

Mean highest temperature	33.6°
Mean lowest temperature	18.7°
Mean temperature for month	26.2°
Total precipitation for month	1.03

WEATHER

Number days clear	4
Partly cloudy	6
Cloudy	21
With 0.01 inch or more of precipitation	10

SUNSHINE

Number hours sunshine	92.2
Possible hours sunshine	280.8
Percentage of possible	33

BAROMETER—Mean, 30.08 inches; highest, 30.59 inches, on 6th; lowest, 29.55 inches, on 8th.

TEMPERATURE—Highest, 57°, on 1st; lowest, 2°, on 18th; greatest daily range, 34°, on 8th.; least daily range, 3°, on 24th; normal temperature, 26.8°; departure, —0.6°; accumulated departure since January 1, +621°; average daily departure since January 1, +1.7°; highest in 37 years, 62°; lowest, —24°.

PRECIPITATION (in inches)—Total this month, 1.03; normal, 2.08; departure, —1.05; since January 1, —3.00; greatest amount in 24 hours, 0.29, on 4th; total snowfall, 4.3 in.

WIND—Prevailing direction, west; total movement, 5,499 miles; average hourly velocity, 7.4 miles; maximum velocity, 24 miles per hour, from west, on 12th.

DATES OF—Auroras, 0; hail, 0; sleet, 0; fog, dense, 7, 26; thunderstorms, 0; halos, solar, 16, 20, 26, 30; halos, lunar, 26, 30; frost, killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, JANUARY, 1923.

Date.	Temperature.			Precipitation in inches.	Character of day	Percentage of possible sunshine
	Highest	Lowest	Mean			
1	30	25	28	T.	Cloudy	0
2	33	22	28	0.01	Cloudy	3
3	33	13	23	0.09	Cloudy	0
4	30	14	22	0.03	Cloudy	8
5	31	22	26	T.	Cloudy	0
6	22	6	14	0.08	Clear	85
7	26	11	18	0.01	Cloudy	0
8	30	22	26	0.24	Cloudy	0
9	32	26	29	0.10	Cloudy	2
10	26	3	14	T.	Cloudy	22
11	28	3	16	0.02	Cloudy	2
12	28	16	22	0.02	Cloudy	8
13	30	13	22	0.08	Partly Cloudy	70
14	38	28	33	0.30	Cloudy	0
15	37	24	30	T.	Cloudy	23
16	24	0	12	0.02	Cloudy	24
17	31	−5	13	0	Cloudy	14
18	43	20	32	0	Partly Cloudy	36
19	24	13	18	0.19	Cloudy	29
20	43	21	32	0	Cloudy	29
21	28	20	24	0	Partly Cloudy	71
22	25	7	16	0.02	Partly Cloudy	75
23	29	6	18	0	Partly Cloudy	100
24	34	28	31	0.23	Cloudy	6
25	28	16	22	0.02	Cloudy	47
26	40	22	31	0	Partly Cloudy	36
27	26	22	24	0.01	Cloudy	0
28	30	24	27	0.01	Cloudy	0
29	32	18	25	0	Partly Cloudy	57
30	32	14	23	0.08	Partly Cloudy	78
31	37	30	34	0.09	Cloudy	0

Mean highest temperature	31.0°
Mean lowest temperature	16.3°
Mean temperature for month	23.6°
Total precipitation for month	1.65

Weather

Number days clear	1
Partly cloudy	8
Cloudy	22
With 0.01 inch or more of precipitation	20

Sunshine

Number hours sunshine	78.8
Possible hours sunshine	292.5
Percentage of possible	27

This month since 1863		
Year.	Mean temperature.	Total precipitation.
1863		
1864	22.3	0.94
1865	21.1	0.65
1866	21.2	2.03
1867	17.6	1.68
1868	19.0	1.47
1869	29.4	0.87
1870	25.4	1.93
1871	24.8	3.95
1872	21.6	0.42
1873	15.9	2.98
1874	27.7	3.53
1875	12.9	1.81
1876	30.2	1.63
1877	18.1	1.33
1878	29.1	1.12
1879	19.2	0.49
1880	37.1	2.67
1881	17.0	2.27
1882	24.9	1.47
1883	14.4	1.53
1884	15.5	1.23
1885	15.3	2.70
1886	18.8	2.66
1887	18.2	3.25
1888	15.4	2.18
1889	28.0	1.53
1890	31.5	2.31
1891	26.7	0.82
1892	19.2	0.96
1893	14.8	1.78
1894	26.9	1.37
1895	17.5	1.04
1896	24.6	0.79
1897	22.3	4.17
1898	24.9	3.07
1899	21.7	2.03
1900	25.6	1.17
1901	22.2	1.51
1902	20.5	0.43
1903	20.7	1.20
1904	14.4	2.82
1905	18.2	1.07
1906	31.8	1.99
1907	23.2	3.97
1908	23.8	1.89
1909	26.6	2.16
1910	23.4	2.52
1911	25.2	1.43
1912	9.2	0.80
1913	26.2	3.10
1914	27.0	2.98
1915	20.4	1.54
1916	27.6	3.11
1917	21.0	1.55
1918	10.2	2.08
1919	28.5	0.36
1920	13.2	1.34
1921	29.2	0.41
1922	21.0	1.23
1923	23.6	1.65
Normal	22.7	2.09

Barometer—Mean, 30.05 inches; highest, 30.76 inches, on 23rd; lowest, 29.49 inches, on 11th.

Temperature—Highest, 43°, on 20th; lowest, −5°, on 17th; greatest daily range, 36° on 17th; least daily range, 4° on 27th; normal temp., 22.7°; departure, +0.9°; accumulated departure since January 1, +30°; average daily departure since January 1, +0.9°; highest in 38 years, 63°; lowest, —26°.

Precipitation (in inches)—Total this month, 1.65; normal, 2.09; departure, —0.44; since January 1st, —0.44; greatest amount in 24 hours, 0.38, on 13th and 14th; total snowfall, 16.3 inches.

Wind—Prevailing direction, northwest; total movement, 5,330 miles; average hourly velocity, 7.2 miles; maximum velocity, 27 miles per hour from northwest on 14th.

Dates of—Auroras, 0; hail, 0; sleet, 2, 14, 28, 30; fog, dense, 31; thunderstorms, 0; halos, solar, 6, 12, 13, 19, 20, 23, 25, 29; halos, lunar, 0; frost, killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, FEBRUARY, 1923.

Date	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	38	24	31	0.06	Cloudy	0
2	32	18	25	0.03	Cloudy	0
3	27	-3	12	0.04	Cloudy	22
4	11	-3	4	0.01	Cloudy	48
5	18	-1	8	0	Clear	100
6	16	11	14	0.07	Cloudy	0
7	28	12	20	0.06	Cloudy	10
8	38	15	26	0	Partly Cloudy	60
9	20	13	16	0.03	Cloudy	29
10	28	9	18	0.01	Partly Cloudy	72
11	25	8	16	0.01	Clear	81
12	33	10	22	0.24	Cloudy	8
13	30	15	22	0.12	Cloudy	0
14	15	2	8	0.08	Cloudy	52
15	12	0	6	T.	Clear	100
16	14	2	8	0.01	Cloudy	39
17	12	-2	5	0.01	Partly Cloudy	87
18	18	4	11	0.01	Cloudy	21
19	26	9	18	0.06	Partly Cloudy	61
20	29	5	17	0.06	Clear	94
21	29	4	16	0.02	Cloudy	7
22	26	13	20	0.01	Partly Cloudy	66
23	16	0	8	0	Clear	100
24	37	2	20	0.06	Cloudy	4
25	40	17	28	0	Partly Cloudy	76
26	39	30	34	0	Cloudy	5
27	34	26	30	0	Cloudy	47
28	36	24	30	0.01	Cloudy	31
29						
30						
31						

Mean highest temperature	26.0°
Mean lowest temperature	9.4°
Mean temperature for month	17.7°
Total precipitation for month	1.01

WEATHER

Number days clear	5
Partly cloudy	6
Cloudy	17
With 0.01 inch or more of precipitation	21

SUNSHINE

Number hours sunshine	129.0
Possible hours sunshine	295.2
Percentage of possible	44

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863		
1864	27.3	0.27
1865	27.6	1.76
1866	22.7	2.28
1867	30.9	3.23
1868	18.7	1.28
1869	26.7	2.95
1870	24.2	1.20
1871	25.6	1.73
1872	21.3	0.46
1873	19.1	0.77
1874	25.5	1.55
1875	8.0	2.20
1876	27.4	3.04
1877	32.3	0.00
1878	28.1	2.74
1879	20.4	1.43
1880	29.2	1.62
1881	21.6	3.77
1882	35.1	2.28
1883	19.8	4.50
1884	23.4	3.69
1885	8.9	0.73
1886	22.3	1.35
1887	24.3	5.71
1888	22.0	1.70
1889	18.3	1.17
1890	31.5	1.79
1891	26.7	2.20
1892	27.3	1.93
1893	21.3	1.83
1894	21.2	0.53
1895	16.4	0.12
1896	24.3	1.51
1897	26.4	0.67
1898	23.8	1.82
1899	16.8	1.51
1900	17.4	3.44
1901	12.8	1.83
1902	18.6	0.44
1903	20.6	1.58
1904	12.0	3.30
1905	15.8	1.25
1906	23.6	1.12
1907	19.2	0.25
1908	21.6	3.19
1909	28.4	2.36
1910	21.9	2.65
1911	27.6	1.77
1912	15.8	2.04
1913	20.0	1.65
1914	12.7	0.79
1915	29.4	2.10
1916	19.2	0.69
1917	15.5	0.62
1918	21.8	3.04
1919	27.0	1.50
1920	19.8	0.81
1921	28.3	1.25
1922	26.0	0.97
1923	17.7	1.01
Normal	21.6	2.02

BAROMETER—Mean, 30.14 inches; highest, 30.59 inches, on 23rd; lowest, 29.61 inches, on 12th.

TEMPERATURE—Highest, 40°, on 25th; lowest, —3°, on 3rd; greatest daily range, 35°, on 24th; least daily range, 5°, on 6th; normal temperature, 21.6°; departure, —3.9°; accumulated departure since January 1, —82°; average daily departure since January 1, —1.4°; highest in 38 years, 62°; lowest, —25°.

PRECIPITATION (in inches)—Total this month, 1.01; normal, 2.02; departure, —1.01; since January 1st, —1.45; greatest amount in 24 hours, 0.24, on 12th; total snowfall, 11.0 inches.

WIND—Prevailing direction, northwest; total movement, 4,803 miles; average hourly velocity, 7.1 miles; maximum velocity, 29 miles per hour from northwest, on 14th.

DATES OF—Auroras, 0; hail, 0; sleet, 2, 12, 28; fog, dense, 26; thunderstorms, 0; halos, solar, 14, 19, 27; halos, lunar, 1, 25, 27; frost, killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, MARCH, 1923.

Date.	Temperature.			Precipitation in inches.	Character of day	Percentage of possible sunshine
	Highest	Lowest	Mean			
1	35	32	34	0	Cloudy	25
2	56	34	45	0	Clear	98
3	53	36	44	0.25	Partly Cloudy	76
4	48	26	37	0.18	Cloudy	0
5	33	19	26	T.	Partly Cloudy	94
6	32	26	29	0.09	Cloudy	0
7	30	21	26	0.02	Cloudy	48
8	30	14	22	T.	Partly Cloudy	70
9	42	22	32	0.26	Cloudy	58
10	39	28	34	0.01	Clear	100
11	45	28	36	0.03	Cloudy	72
12	43	24	34	0.95	Cloudy	1
13	27	15	21	0.05	Cloudy	40
14	27	14	20	0.03	Cloudy	67
15	44	24	34	0.55	Cloudy	25
16	47	18	32	0.20	Partly Cloudy	47
17	42	18	30	0	Clear	100
18	41	7	24	0.17	Cloudy	48
19	16	-1	8	0.01	Clear	100
20	39	7	23	T.	Partly Cloudy	53
21	49	34	42	0	Cloudy	93
22	53	39	46	0.19	Cloudy	11
23	39	28	34	T.	Cloudy	0
24	33	22	28	0	Clear	100
25	40	11	26	0.03	Cloudy	22
26	32	9	20	0	Clear	100
27	39	17	28	T.	Clear	86
28	18	7	12	T.	Partly Cloudy	79
29	44	9	26	T.	Cloudy	38
30	30	6	18	0.02	Cloudy	57
31	21	4	12	0	Partly Cloudy	97

This month since 1863		
Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	31.7	2.26
1865	37.0	2.79
1866	29.1	3.39
1867	29.7	0.68
1868	37.8	4.65
1869	27.6	1.65
1870	30.3	3.01
1871	38.2	3.91
1872	24.8	2.04
1873	28.3	1.73
1874	32.3	1.79
1875	26.2	1.02
1876	30.6	4.84
1877	24.5	5.60
1878	40.9	3.12
1879	33.2	1.57
1880	35.5	1.70
1881	30.3	2.66
1882	36.0	3.58
1883	24.9	0.71
1884	29.9	3.67
1885	21.3	0.58
1886	31.3	2.63
1887	28.3	1.78
1888	27.0	1.88
1889	37.6	1.22
1890	28.2	1.54
1891	29.3	2.41
1892	29.9	1.31
1893	28.2	2.82
1894	40.1	1.25
1895	27.2	0.27
1896	28.7	1.31
1897	33.0	2.08
1898	37.0	3.59
1899	26.3	3.30
1900	23.6	1.88
1901	31.1	2.94
1902	38.0	3.16
1903	41.0	1.25
1904	30.2	3.45
1905	35.4	3.15
1906	26.2	1.86
1907	38.6	2.84
1908	34.8	2.19
1909	29.9	0.90
1910	44.0	0.40
1911	32.7	1.21
1912	22.4	1.92
1913	31.0	3.76
1914	31.1	1.52
1915	30.1	0.78
1916	26.2	3.09
1917	34.6	2.88
1918	37.1	3.58
1919	33.8	3.48
1920	35.2	3.57
1921	40.4	3.34
1922	35.4	3.69
1923	28.4	3.04
Normal	32.3	2.26

Mean highest temperature	37.6°
Mean lowest temperature	19.3°
Mean temperature for month	28.4°
Total precipitation for month	3.04

WEATHER

Number days clear	7
Partly cloudy	7
Cloudy	17
With 0.01 inch or more of precipitation	17

SUNSHINE

Number hours sunshine	216.4
Possible hours sunshine	370.5
Percentage of possible	58

BAROMETER—Mean, 29.99 inches; highest, 30.57 inches, on 31st; lowest, 28.96 inches, on 12th.

TEMPERATURE—Highest, 56°, on 2nd; lowest, —1°, on 19th; greatest daily range, 35°, on 29th; least daily range, 3°, on 1st; normal temperature, 32.3°; departure, —3.9°; accumulated departure since January 1, —200°; average daily departure since January 1, —2.2°; highest in 38 years, 82°; lowest, —12°.

PRECIPITATION (in inches)—Total this month, 3.04; normal, 2.26; departure, +0.78; since January 1st, —0.67; greatest amount in 24 hours, 0.98, on 11th and 12th; total snowfall, 12.7 inches.

WIND—Prevailing direction, northwest; total movement, 6,899 miles; average hourly velocity, 9.3 miles; maximum velocity, 34 miles per hour from southwest on 12th.

DATES OF—Auroras, 0; hail, 0; sleet, 12; fog, dense, 0; thunderstorms, 9, 16; halos, solar, 2, 3, 9, 11, 14, 15, 19, 21, 24, 25, 29; halos, lunar, 0; frost, killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, APRIL, 1923

Date	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	36	8	22	T.	Partly Cloudy	90
2	64	36	50	0.06	Partly Cloudy	88
3	49	32	40	0.47	Cloudy	0
4	40	28	34	0	Cloudy	47
5	43	27	35	T.	Cloudy	31
6	58	26	42	0	Clear	100
7	60	33	46	0.06	Cloudy	42
8	49	22	36	0.01	Partly Cloudy	82
9	40	21	30	0	Cloudy	85
10	46	31	38	0.04	Partly Cloudy	55
11	46	24	35	0.15	Partly Cloudy	42
12	57	21	39	0	Clear	100
13	42	27	34	0	Cloudy	65
14	44	27	36	0.09	Cloudy	46
15	39	31	35	0.17	Cloudy	0
16	46	29	38	T.	Partly Cloudy	66
17	49	27	38	0	Clear	96
18	65	35	50	0	Clear	100
19	76	37	56	0	Clear	100
20	80	52	66	0	Clear	100
21	74	50	62	0.35	Cloudy	66
22	52	48	50	0.07	Cloudy	9
23	58	36	47	0	Clear	100
24	58	30	44	0	Clear	100
25	67	32	50	0	Clear	100
26	71	35	53	0	Partly Cloudy	86
27	73	46	60	0.09	Partly Cloudy	61
28	64	39	52	0	Partly Cloudy	84
29	60	33	46	T.	Cloudy	42
30	70	41	56	0	Clear	100
31	....	....	....	....	....	....

Mean highest temperature	55 9°
Mean lowest temperature	32.1°
Mean temperature for month	44 0°
Total precipitation for month	1.56

Weather

Number days clear	10
Partly cloudy	9
Cloudy	11
With 0.01 inch or more of precipitation	11

Sunshine

Number hours sunshine	280.5
Possible hours sunshine	402.5
Percentage of possible	70

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	45.9	3.80
1865	47.4	2.32
1866	48.9	1.40
1867	48.2	2.19
1868	43.7	1.83
1869	45.7	3.42
1870	50.4	2.02
1871	49.8	2.97
1872	47.4	1.26
1873	43.2	3.88
1874	36.9	1.67
1875	41.1	0.61
1876	44.2	2.08
1877	46.2	4.14
1878	50.6	3.76
1879	44.8	1.25
1880	45.9	7.06
1881	45.6	1.73
1882	44.7	1.88
1883	43.5	1.90
1884	43.7	1.95
1885	43.6	2.47
1886	50.2	1.99
1887	45.4	0.90
1888	44.0	1.15
1889	46.6	2.02
1890	47.2	3.20
1891	47.4	1.74
1892	44.5	2.04
1893	43.5	4.81
1894	48.4	2.76
1895	48.6	0.67
1896	52.6	2.77
1897	44.6	2.74
1898	43.6	2 12
1899	49.8	1.23
1900	47.4	2.00
1901	46.4	2.16
1902	44.6	1.70
1903	43.0	4.40
1904	39.4	0.50
1905	44.6	1.49
1906	46.6	2.43
1907	37.8	2.81
1908	44.6	2.15
1909	42 8	5 96
1910	49 2	2 48
1911	44.3	2.11
1912	45.6	3.12
1913	45.9	3.10
1914	44.7	2.90
1915	51.6	1.00
1916	45.7	1.91
1917	42.4	5.59
1918	42.4	1.97
1919	44.8	4.13
1920	39.9	3.25
1921	51.6	3.80
1922	46.8	3.75
1923	44.0	1.56
Normal	45.6	2.54

Barometer—Mean, 29.96 inches; highest, 30.58 inches, on 1st; lowest, 29.36 inches, on 7th.

Temperature—Highest, 80° on 20th; lowest, 8°, on 1st; greatest daily range, 39° on 19th; least daily range, 4°, on 22nd; normal temperature, 45.6°; departure, —1.6°; accumulated departure since January 1, —249°; average daily departure since January 1, —2.1°; highest in 38 years, 88°; lowest, 8°.

Precipitation (in inches)—Total this month, 1.56; normal, 2.54; departure, —0.98; since January 1st, —1.65; greatest amount in 24 hours, 0.53, on 2nd and 3rd; total snowfall, 3.1 inches.

Wind—Prevailing direction, northwest; total movement, 5,940 miles; average hourly velocity, 8.2 miles; Maximum velocity, 25 miles per hour from west on 8th.

Dates of—Auroras, 0; hail, 0; sleet, 0; fog, dense, 0; thunderstorms, 21, 27; halos, solar, 2,4,5,9,13, 14, 17, 21, 26; halos, lunar, 0; frost, killing, 8, 9; 12, 24; heavy, 25; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, MAY, 1923

Date.	Temperature.			Precipitation in inches.	Character of day	Percentage of possible sunshine
	Highest	Lowest	Mean			
1	73	37	55	0	Clear	100
2	70	38	54	0	Clear	100
3	70	39	57	0	Partly Cloudy	82
4	73	40	56	0	Partly Cloudy	86
5	65	38	52	0	Clear	100
6	70	36	53	0	Clear	100
7	75	40	58	0.16	Partly Cloudy	87
8	60	34	47	0.23	Cloudy	37
9	42	29	36	0.85	Cloudy	37
10	59	26	42	0	Clear	99
11	69	43	56	0	Cloudy	56
12	58	35	46	0.04	Cloudy	34
13	59	28	44	0	Clear	99
14	64	42	53	0.13	Partly Cloudy	81
15	72	44	58	0.33	Cloudy	11
16	57	39	48	1.45	Cloudy	0
17	60	38	49	0	Partly Cloudy	79
18	69	34	52	0	Clear	96
19	75	49	62	T.	Partly Cloudy	78
20	69	45	57	0.26	Cloudy	43
21	58	40	49	0	Partly Cloudy	69
22	65	38	52	0	Cloudy	100
23	67	40	54	0	Clear	100
24	72	37	54	0	Clear	100
25	79	40	60	0	Clear	97
26	82	46	64	0	Clear	97
27	81	54	68	0	Clear	87
28	82	47	64	0	Clear	100
29	84	50	67	0	Clear	100
30	77	47	62	0	Clear	100
31	84	46	65	0	Clear	100

Mean highest temperature	69 2°
Mean lowest temperature	40 0°
Mean temperature for month	54 6°
Total precipitation for month	3.45

WEATHER

Number days clear	16
Partly cloudy	7
Cloudy	8
With 0.01 inch or more of precipitation	8

SUNSHINE

Number hours sunshine	360 4
Possible hours sunshine	454 7
Percentage of possible	79

This month since 1863		
Year.	Mean temperature.	Total precipitation.
1863		
1864	60 2	2 87
1865	57.6	1.77
1866	55 0	3.48
1867	61.1	3 80
1868	59.1	2 80
1869	56 0	2 05
1870	64 3	1.16
1871	61.4	1 97
1872	58.5	3 72
1873	56 9	3.05
1874	59 6	1 77
1875	60 8	4.46
1876	58.0	4 13
1877	58 2	2 23
1878	54 6	3 44
1879	58 8	2.45
1880	64 3	5 59
1881	65 2	2 11
1882	52.7	4 04
1883	52 8	5 66
1884	56 9	3.95
1885	55 8	2 30
1886	58 1	2 67
1887	64.3	2 42
1888	53 7	3 66
1889	57.4	3 61
1890	53 7	4 98
1891	55 7	1 63
1892	54 5	5.92
1893	54 4	2 86
1894	56.9	4.83
1895	61 8	2.06
1896	66 5	3 14
1897	55.8	3.29
1898	56 5	2 15
1899	58 8	3 59
1900	58.8	4 17
1901	55 2	2 42
1902	58.4	4 92
1903	59 5	2 63
1904	57.4	2 40
1905	56 7	5 17
1906	56 6	3 05
1907	51.2	2 22
1908	59.6	5 59
1909	55.8	2 44
1910	51.5	4 13
1911	63 5	2 67
1912	57.6	6.57
1913	56.2	2.22
1914	58 6	4.66
1815	51 5	2.74
1916	56 6	5.13
1917	50.2	3 37
1918	61 1	2 89
1919	54 5	4 29
1920	55.1	1.43
1921	60.4	1 33
1922	62 6	3 39
1923	54 6	3 45
Normal	57.1	3 58

BAROMETER—Mean, 29.96 inches; highest, 30.39 inches, on 23rd; lowest, 29.33 inches, on 16th.

TEMPERATURE—Highest, 80°, on 29th; lowest, 26°, on 10th; greatest daily range, 39°, on 25th; least daily range, 13°, on 9th normal temperature, 57.1°; departure, —2.5°; accumulated departure since January 1, —323°; average daily departure since January 1, —2.1°; highest in 38 years, 95°; lowest, 17°.

PRECIPITATION (in inches)—Totals this month, 3.45; normal, 3.58; departure, —0.13; since January 1st, —1.78. greatest amount in 24 hours, 1.62, on 15th and 16th; total snowfall, 11.5 inches.

WIND—Prevailing direction, east; total movement, 4,379 miles; average hourly velocity, 5.9 miles; maximum velocity, 19 miles per hour, from northwest on 16th.

DATES OF—Auroras, 18; hail, 0; sleet, 0; fog, dense, 0; thunderstorms, 19, 20; halos, solar, 2, 3, 4, 9, 14, 15, 17, 22, 24; halos, lunar, 3, 4; frost, killing, 10, 13; heavy, 18, light, 4, 6, 23, 24.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, JUNE, 1923

Date	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	89	54	72	0.08	Partly Cloudy	91
2	86	65	76	0.04	Partly Cloudy	89
3	84	67	76	0	Partly Cloudy	76
4	87	70	78	0.03	Partly Cloudy	88
5	89	69	79	0	Partly Cloudy	99
6	72	62	67	0.23	Cloudy	25
7	77	49	63	0.49	Cloudy	27
8	71	50	60	0.01	Partly Cloudy	77
9	76	46	61	0	Clear	99
10	76	50	63	0	Cloudy	72
11	79	57	68	0	Cloudy	59
12	81	54	68	0	Clear	96
13	82	52	67	0	Clear	86
14	83	52	68	0.13	Cloudy	37
15	76	52	64	T.	Partly Cloudy	46
16	82	53	68	0	Partly Cloudy	83
17	88	55	72	0	Clear	100
18	90	65	78	0	Partly Cloudy	91
19	85	68	76	T.	Cloudy	36
20	90	68	79	T.	Partly Cloudy	82
21	93	67	80	0.59	Partly Cloudy	75
22	92	66	79	0.44	Partly Cloudy	78
23	95	67	81	0	Partly Cloudy	82
24	93	67	80	0	Clear	100
25	92	65	78	0.03	Partly Cloudy	83
26	77	59	68	0.02	Partly Cloudy	78
27	77	52	64	T.	Cloudy	54
28	62	48	55	0.61	Cloudy	12
29	69	41	55	0	Partly Cloudy	97
30	74	46	60	0.20	Partly Cloudy	62
31						

Mean highest temperature	82.2°
Mean lowest temperature	57.9°
Mean temperature for month	70.0°
Total precipitation for month	2.90

WEATHER

Number days clear	5
Partly cloudy	17
Cloudy	8
With 0.01 inch or more of precipitation	13

SUNSHINE

Number hours sunshine	334.5
Possible hours sunshine	459.4
Percentage of possible	73

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863		
1864	67.6	3.88
1865	70.8	3.55
1866	66.6	5.37
1867	71.6	2.83
1868	68.5	3.55
1869	64.4	4.40
1870	70.9	7.27
1871	68.2	2.93
1872	71.8	3.45
1873	70.6	2.96
1874	70.6	5.07
1875	66.6	1.84
1876	68.1	4.34
1877	65.9	3.53
1878	64.1	3.15
1879	66.0	2.87
1880	67.6	5.04
1881	64.3	4.37
1882	66.5	5.57
1883	65.9	11.35
1884	68.9	2.83
1885	64.7	6.01
1886	65.7	1.92
1887	68.5	2.47
1888	67.9	2.51
1889	62.8	3.42
1890	70.3	3.92
1891	67.4	2.55
1892	67.7	4.33
1893	66.6	4.85
1894	71.4	1.30
1895	71.4	1.01
1896	69.9	2.60
1897	64.2	2.57
1898	67.6	4.91
1899	68.2	1.15
1900	65.2	2.57
1901	68.0	3.57
1902	61.8	7.28
1903	62.0	6.28
1904	65.6	2.49
1905	66.2	7.47
1906	67.1	4.61
1907	65.0	2.37
1908	70.0	1.23
1909	66.7	2.86
1910	64.9	1.95
1911	68.0	3.77
1912	63.1	0.97
1913	67.6	1.01
1914	66.0	4.11
1915	61.0	3.96
1916	61.4	5.39
1917	62.4	4.54
1918	64.4	2.07
1919	71.9	3.18
1920	67.7	4.17
1921	70.6	3.24
1922	67.4	1.83
1923	70.0	2.90
Normal	67.2	3.40

BAROMETER—Mean, 29.94 inches; highest, 30.26 inches, on 9th; lowest; 29.52 inches, on 26th.

TEMPERATURE—Highest, 95°, on 23rd; lowest, 41° on 29th; greatest daily range, 35°, on 1st; least daily range, 10°, on 6th; normal temperature, 67.2°; departure, +2.8°; accumulated departure since January 1, —235°; average daily departure since January 1, —1.3°; highest in 38 years, 99°; lowest, 34°.

PRECIPITATION (in inches)—Total this month, 2.90; normal, 3.40; departure, —0.50; since January 1st, —2.28; greatest amount in 24 hours, 0.61. on 28th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southwest; total movement, 3,018 miles; average hourly velocity, 4.2 miles; maximum velocity, 24 miles per hour from southwest on 21st.

DATES OF—Auroras, 0; hail, 0; sleet, 0; fog, dense, 6, 16; thunderstorms, 1, 2, 6, 7, 14, 19, 20, 21, 22, 24, 25, 26, 30; halos, solar, 17, 18, 27; halos, lunar, 0; frost, killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

REPORT OF THE DEPARTMENT OF HISTORY AND POLITICAL SCIENCE.

Sir:—In conformity with the custom, I hereby present to you a brief report of the Department of History and Political Science for the academic year 1922-1923.

For the most part the work of the Department has been the same as for the several preceding years. We have continued giving to our students the elementary courses in History and Government which have long been used in this College. In conducting this work the full time of Mrs. Hendrick and myself has been required; in fact, we have found more hours of teaching than is normally possible for one to do thoroughly. This was due partly to the demands of the aforesaid subjects, and in part was due to the fact that we have offered some advanced courses for the first time in the past year. This aspect of the work found expression in a course in English History to the students of the Home Economics, Agriculture and Applied Science Divisions; also a course in the study of special periods. This year the class studied the administration of Theodore Roosevelt. The object of this course is to make an intensive study of a brief period of time with the view of becoming thoroughly acquainted with all of the forces, political, economic and social, that may be found working in a period of exceptional interest.

In the field of Government we have offered two new courses; one in the winter term in the study of "World Organization" in which we sought to acquaint the student with some exact information as to the procedure and accomplishment thus far, in the way of international organization and control. In the spring term a second new course was given in the form of Municipal Government—thus for the first time has a course of this kind been attempted at M. A. C. Finally, I would draw attention to the fact that two sections of students were enrolled in the course of Industrial History under the direction of Assistant Professor R. S. Steiner. In this course we seek to acquaint the student with some account of the development of industry during the centuries of the past, starting our intensive study with the development of English Industry in the 18th century and tracing the course of industrial progress from that date throughout our American History with the view of laying a great deal of emphasis upon the Industrial Revolution and its effect upon human progress. It is our hope that an acquaintance with the various aspects of industrial development may be of real value to students in the pursuit of other lines of work in the College. We persist in our contention that students need a greater degree of familiarity with the facts of the past in order to be more efficient students of the present. One obvious fallacy on the part of so many students is that they think because they pursue certain fields of History in High School they have exhausted the value of such study, whereas they have in reality simply acquired the tools whereby to do some real effective study in connection with the training in thinking which the College period of education provides them. It is a matter of satisfaction to the members of this department to find so large a number of our students realizing this point of view during their College career and making use of their opportunities in this connection.

Mrs. Hendrick has continued in her capacity in this department during the year in her usual effective way.

During the spring term Mr. Steiner joined our force for the work in Industrial History which he conducted with satisfaction.

Respectfully submitted,
E. H. RYDER,
Professor of History and Political Science.

REPORT OF THE DEPARTMENT OF MUSIC.

To the President:

Sir:—The report of the Music Department for the year ending June 30, 1923, is as follows:

The department personnel:

John Siebert Taylor, Professor of Voice.
Delia H. Bemis, Instructor in Violin.
Mrs. Gertrude L. Clark, Instructor in Piano.
Miss Mildred Koonsman, Instructor in Piano.
Miss Patricia McDonald, Instructor in Voice.
Mr. Glenn H. Bradt, Instructor in Band Inst.
Mr. Carl H. Dewey, Instructor in Band Inst.

Number of students enrolled:

Piano	93
Voice	126
Violin	35
Harmony	20
Band Inst.	90
Summer School	5
Total	369

These students received one lesson a week with five hours practice. Recitals were given from time to time by those qualified. Music was furnished as usual for occasions both on and off the campus. The Men's Glee Club was up to the usual high standard, and with the Band gave concerts in Saginaw, Bay City, Midland, Pontiac, Lansing and East Lansing. This trip was so successful that we were requested to make it an annual event in these cities.

The Band of course belongs to the Military Department, but through the Music Department we are giving lessons to all members who desire them, thus improving the organization by improving the individual. About 65 per cent of the Band members availed themselves of this opportunity. The same plan has been in operation in the Glee Club for the last four years.

The Orchestra of 20 members did excellent work for their second year. Besides giving concerts they played for many other occasions including Commencement Day exercises. It is a valuable addition to the campus.

Respectfully submitted,
J. S. TAYLOR,
Director of Music.

REPORT OF THE DEPARTMENT OF PHYSICS.

To the President:

Sir:—A brief record of the Physics Department for the school year ending June 30, 1923, follows:

There was no change in the personnel of the department throughout the year.

Due to the lack of an Associate Professor requested in my budget, as well as insufficient funds with which to provide suitable equipment, together with inadequate laboratory space, the department was prohibited from offering (although students had requested us to give them) the catalogued courses, listed below:

Physics 4c. *Mechanics Applied*—Spring Term.
Elective for Agricultural and Forestry Courses.

Physics 6g. *Electron Theory*—Fall Term.
Elective for Seniors in Science Course.

Physics 6i. *Heat Measurements*—Spring Term.
Elective for Seniors in Science Course.

For the same reasons, these courses will not be given during the coming year.

Two of the new scheduled courses,—

Physics 4d. *Electrical Measurements*—Winter, Summer Term.
Elective for Science Course.

Physics 6n. *Advanced Optics*—Spring Term.

were given for the first time. This was made possible since the southeast corner room, first floor (Forestry Building), was made available for use during these terms.

A partition was put in the East Lecture Room, thus cutting off the north twelve feet, to provide space in which to carry on research work for graduate students.

The unexpended portion of the 1921-22 apportionment for equipment, was returned to the department as its allowance for equipment during the past year. The department could have eked out an existence on this apportionment had it not been for the fact that the receipts of the Photographic Division were taken from the department in February, and turned over into the College general fund. However, the department has enlarged its scope, this year, as shown by the following evidence:

One student has started his major in physics in the Graduate School.

Two Undergraduate students (Applied Science Course) majored in physics.

Four Undergraduate students (Applied Science Course) minored in physics.

The outlook for the ensuing year is much better due to the increased apportionment allotted the department, and because the receipts of the Photographic Division will provide a rotating fund with which to purchase the supplies for the work of other departments on the Campus.

In order to complete our program of courses, as outlined by the Faculty, we will have to enlarge our staff for the year 1923-24.

Respectfully submitted,
CHAS. W. CHAPMAN,
Professor of Physics.

REPORT OF THE DEPARTMENT OF PHYSICAL TRAINING.

To the President

Sir:—I submit for your consideration the following report on the work of the department of Physical Education for the year ending June 30, 1923:

The teaching staff for the year was as follows:
A. M. Barron, Acting Director of Athletics.
L. L. Frimodig, Assistant Director of Athletics.
F. M. Walker, Instructor.
L. D. Burhans, Instructor.
R. H. Rauch, Instructor.
J. G. Heppinstall, Instructor.
J. H. Devers, Instructor.
Helen Grimes, Instructor.
Grace Keefe, Instructor.
Blanche Vaughn, Instructor.

It has been the aim of this department to induce as large a number of students as possible to participate in athletic events and training and to take advantage of the classes in physical exercise and contests arranged by the department. With the idea of benefiting the whole student body we have encouraged intramural games and have had about 700 students engaged in some sport at various times during the year.

Physical Education was required of Freshmen and Sophomores only. The first year work consisted of training in army physical drill, calisthenics, mass and recreative games. In addition they were given lectures in health education and public hygiene. The second year men were given their choice of the afore-mentioned activities or engaging in varsity athletics.

The upper classmen took exercise in intramural athletics. Schedules were arranged for both class and society competition in basketball, track, indoor baseball, outdoor baseball, swimming, bowling and tennis.

Physical education for girls is required of Freshmen and Sophomores, three hours a week, and elective for upper classmen. A physical and medical examination is required of all new students. A general program of athletics, corrective work, swimming, which is a required subject, is given all under-classmen. The interclass sports are hockey, soccer, basketball, baseball, and swimming. Varsity sports are tennis and rifle, while the inter-sorority sports are rifle, bowling, archery, swimming and tennis. Upperclassmen are given a two-year elective course in physical education which is correlated with various departments of the college, such as home economics, art, music, military science, veterinary science, and bacteriology, which gives a splendid, well-rounded out course.

Varsity and Freshmen teams were maintained in football, basketball, baseball, track, swimming, wrestling, and tennis. Our teams competed with the leading teams of the Western Conference and the Middle West. We won a representative number of our games with the strongest colleges and universities, and always put up a fight which won respect and admiration from friends and rivals alike.

The new concrete stadium now under construction will fill a long-felt want. The old stands are about worn out and entirely inadequate. The gymnasium is splendidly equipped. In fact our athletic plant will be one of the best in the Middle West. The great need, however, is more playgrounds, so that a more extensive program may be carried out, and so that we may be able to get every student in the institution in some sort of recreation. Another big need is an auditorium so the work of the department may not be hampered by the continual use of the gymnasium for other college functions.

I respectively call your attention to the fact that the department touches the life of every student in the institution. The contact is a vital one, playing an important part in the well-rounded man and woman.

Respectfully submitted,
L. L. FRIMODIG,
Assistant Director of Athletics.

REPORT OF THE SUMMER SESSION.

To the President:

Sir:—The Summer Session, 1923, opened on Tuesday, June 19th, and closed on Friday, July 27th. This date of opening was immediately following Commencement. This year's experience directs attention to two things. In the first place, a brief interval of rest between the end of the spring term and the opening of the Summer Session would be advantageous to Faculty and student. Besides, we found ourselves a little in advance of other schools of a similar nature and the closing of High Schools from whose faculties we have drawn a number of students.

The organization has been very similar to that of preceding years. A liberal number of courses has been offered for our regular students for the purpose of removing deficiencies or obtaining advance credit.

In addition the College has furnished special courses for teachers of the rural schools, including Agriculture, Home Economics, Pedagogy and Physical Training.

A special group of courses in Agriculture has been presented to a class of twelve superintendents of schools in the State. The most of these men were here ten weeks last summer for the same purpose. During the two summers these men are covering about fifty credits of Agriculture. This work is done at the request of the Department of Public Instruction as a means of giving men trained in liberal arts institutions some training in technical Agriculture in order to fit them to adequately supervise the Consolidated Schools. These men express sincere appreciation of the spirit of M. A. C. and of the opportunities afforded them by the members of our Faculty who have given them special attention in their respective fields.

We have given again this year the courses in Home Economics designed to assist women to qualify under the Smith-Hughes law as teachers in the High Schools. Several of our graduates of former years have returned to obtain the instruction in these courses given by Miss Margaret Stewart, of Ames, Iowa. Miss Stewart's services were so satisfactory last summer in this same capacity that she was invited to return this year. Another activity of the summer of more than passing interest is the School of Instruction given during the last two weeks to teachers of Agriculture in the High Schools under the direction of Director E. E. Gallup. This year one hundred men enrolled and were given class room instruction by members of the Faculty. The merits of this project are very obvious. It keeps the boys in intimate touch with the College from whence they may get advice, inspiration and instruction. The very latest developments in scientific lines can be placed at their disposal. It offers opportunity to compare notes on methods of teaching a new line of work.

Last but not least—perhaps the most important activity of the summer is the sojourn of more than 250 boys and girls from widely distributed parts of the state under the auspices of Mr. Ray Turner and his staff. These young people, for the most part of High School ages, are prize winners in Boys' and Girls' Club projects. As a reward for their achievements they are given a week's outing on the campus where they are furnished a chosen program. No one can question the value of these experiences to boys and girls just at the threshold of life. To many of them it will be a revelation of unforseen possibilities in life.

It may be of interest to append to this report a tabulation of figures bearing upon our enrollment.

Total number of undergraduate students enrolled		391
Number of men—regular	207	
Number of men—summer only	49	
Number of women—regular	55	
Number of women—summer only	80	
Number of teachers	95	
Number of rural teachers	17	
Number of graduate students	31	
Number of students candidates for advanced degrees		26
Number of teachers of Agriculture		100
Number of Vocational students enrolled in Vocational School taught by College Faculty		34
Total number of students receiving instruction		551

It is a matter of satisfaction that we have had the largest attendance in our history of students who do not belong to the regular student body. Ten states besides Michigan have been represented in our student body this summer; five from Illinois, six from Ohio, two from Wisconsin, three from West Virginia, five from Pennsylvania and one each from Nebraska, Indiana, Kansas, Mississippi and Delaware. In addition we have one from London, England, two from Ontario, Canada and one from Cairo, Egypt.

Efforts have been put forth by the Faculty to make the stay of the students as pleasant as possible. Two College parties were held which were attended by students and members of the Faculty. An enjoyable social occasion was had each time.

A new departure was made in holding a weekly Convocation. One hour was set aside for this purpose at which time all class exercises were discontinued and students and teachers attended a program consisting of music and a short address.

Finally, the Summer School administration brought to the campus on July 17th and 18th the Coffer-Miller Players who presented two evening performances. Monday—Androcles and the Lion, and on Tuesday, The Good-Natured Man. The work of this company was considered by all in attendance as of very high grade. It is to be hoped that entertainment of this superior type may be had each season as a part of our Summer program.

I wish to call attention to courses given in the second six weeks of the Summer. No plans had been authorized for a second session, but in the course of the first six weeks a few groups of students asked to have certain subjects offered for their benefit.

In response to this demand the following courses were authorized by the Board of Agriculture in the July meeting:

Physics 1d—5 cr.
Physics 1e—5 cr.
Civil Engineering 4a—5 cr.
Civil Engineering 4b—5 cr.

Special courses in Agriculture for Superintendents of Schools as follows:

Farm Crops 4—5 cr.
Farm Mechanics 3—5 cr.
Poultry 2—5 cr.
Soils 2b—3 cr.

Courses in Bees, Poultry, Farm Mechanics for Vocational Men. No College credit.

In closing, I wish to acknowledge the co-operation of our teachers in the hard work of this session. The fact that this session is so differently organized from the regular terms, also the fact that considerable portion of the student body is composed of new students, necessitates a great deal of hard labor on the part of the instructors.

Respectfully submitted,
E. H. RYDER,
Director of Summer Session.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY.

To the President:

Sir:—I beg leave to present herewith the annual report of the Department of Zoology and Physiology for the year 1922-1923. For many years past the reports of this Department have been more-or-less perfunctory recitals of the functioning of a department which showed little change in personnel or courses. The year just closed has, however, brought many marked changes of far-reaching importance.

On the morning of February twenty-sixth the College was shocked by the news of the sudden death of Professor Walter Bradford Barrows, for twenty-eight years Head of this Department. During this period of nearly three decades the College has become recognized as a clearing-house for information concerning bird life. The data accumulated through his own observations and his correspondence with other bird students in the state are preserved for the future in Michigan Bird Life, the 822-page book issued as a Special Bulletin of this Department in 1912. This work was so carefully compiled and pains-takingly written that it is said to be the best of its kind ever issued for the Upper Mississippi-Great Lakes region. So long as birds have usefulness and beauty, this work will reflect credit to the author and to the institution he so long served.

At a meeting of the State Board of Agriculture held on March fifth the undersigned was appointed Acting Head of the Department for the remainder of the year. The teaching work for the remainder of the winter term was so modified that courses were carried through to completion without additional help. For the spring term we secured the services of Mr. N. F. Petersen of the University of Nebraska. He took over the laboratory work in Introductory Zoology and the class and laboratory work in General Zoology.

The teaching schedules for the academic year were as follows:

	Fall	Winter	Spring	
Zoology—1 (2 secs.)	67	43	33	Mr. Conger
2, 4	12	5	..	Mr. Barrows
7, 8, 9	19	15	14	Mr. Conger
10, 11, 3	5	5	12	Mr. Conger
12	..	9	..	Mr. Barrows
Physiology—1 (2 secs.)	106	95	31	Mr. Rosebccm
5, 6	..	11	10	Mr. Rosebcom
Geology—1 (2 secs.)	57	38	38	Mr. Stack
4, 2	16	6	..	Mr. Bergquist
6, 7	15	19	..	Mr. Bergquist
8, 9, 10	8	7	10	Mr. Bergquist
12	6	..	..	Mr. Bergquist
	311	253	148	

RECAPITULATION

				Total
Zoology	103	77	59	253
Physiology	106	106	41	253
Geology	102	70	48	220
				726

It will be noticed in the table above, that of the 253 students enrolled in Zoology during the year, 96 were in elective courses, with an average enrollment of ten students per course. In Physiology all courses given were required. In Geology 87 of the 220 students were in elective courses. This, I feel, indicates a growing interest in these sciences on the part of our student body, and is a hopeful sign for the future development of work along these lines.

A complete separation of the three sciences taught in this department had been under consideration for some time past. Present reorganization plans offered a partial solution to the question and the new college year will find Physiology removed from its former associates and incorporated in the Veterinary Division. At present it is deemed inpracticable to elevate Geology to the rank of a separate department, but it is hoped that such a step may be taken in the near future.

After eleven years of service in this Department, the writer will soon sever his connection with the College. The associations of these years have been increasingly pleasant ones and I bespeak for the reorganized department the measure of co-operation which has made possible the expansion and development our courses have received during recent years. I shall watch with interest the growth of the "Greater M. A. C." for which I have helped to labor, and I feel sure that this Department will assume its full share in the realization of that ambition and will continue to grow in value and service to the College and to the State.

Very truly yours,
ALLEN C. CONGER,
Associate Professor of Zoology,
Acting Head of the Department.

REPORT OF THE DEPARTMENT OF LANDSCAPE ARCHITECTURE.

To the President:

Sir:—This department was officially formed by action of the State Board of Agriculture as a distinct and separate department beginning September 1, 1922. Temporary quarters were obtained in the Engineering Building through the courtesy of the Department of Drawing and Design for the term of the school year, after which time it was expected that more ample and desirable facilities for presenting this subject would be available. The department desires to express its appreciation for this courtesy of the Department of Drawing and Design which it feels at times proved quite inconvenient to them. Under these conditions it has not been possible to assemble the laboratory equipment most desired for presenting this work, but it is expected that better facilities will be available for the coming school year.

The subjects in Landscape Architecture offered during the past year were such as had previously been presented in this line by the writer in previous years as part of the course in horticulture. The courses have now been reorganized in such a manner that a student specializing in Landscape Architecture will be able to obtain a much better training in the subject during his junior and senior years as well as to permit students in General Agriculture, Forestry and Home Economics of obtaining some training on certain phases of this work that will be of most value to them.

It seems entirely fitting and proper in making this initial report of the department to express the function and service that the writer feels this department can render to the student body and to the citizens of the state. If education consists of adaptation to environment, the value of a study that develops an interest, love and appreciation for all that pertains to the aesthetic enjoyment of a rural environment would seem to be a very basic and vital part of an agricultural education. That the young men and women passing through this institution may gain a greater satisfaction and a better appreciation of life in a rural environment, it is desirable that they be led to see the beauties of nature and to sense the enjoyment arising from a love of rural landscapes. Therefore, this department desires the opportunity of reaching each student who expects to live in the country and in particular to the young men and women who expect to become teachers, county agricultural agents, or leaders in the rural community.

There is an unlimited demand for students trained in landscape work as superintendents of golf grounds, a field that has not been considered by this institution in the past. Arrangements have now been made with the U. S. Golf Association whereby students desiring to enter this field of service will be given positions during the summer vacation periods on golf grounds to gain the practical experience in this particular type of work and after completing with satisfaction their course in Landscape Architecture they will be prepared to occupy positions as superintendents. A few men are working this summer on golf grounds in preparation for their training in this line.

This department has not been granted the privilege of an extension worker. The demand of citizens of the state for assistance in this field is very great. Letters are daily received asking for advice in the planting of the home grounds and for help in the designing and development of farm grounds, tourist's camps, playgrounds, school grounds, church grounds, and the grounds about rural town buildings. A great deal of the time of the writer has been taken in working upon these plans as well as much of the time of Miss Genevieve Gillette, half-time assistant in the department for the past year. When one considers that the making of each plan requires from four to forty hours of time drafting, the immense amount of work involved may be appreciated. The department, however, was not able to meet all of the demand. Many requests for plans and personal visits had to be refused. The following is a summary of the plans made this year:

1. Civic Problems—	
(a) Parks, Athletic Grounds, Tourist Camps	2
(b) School Grounds	8
(c) Church and other public buildings (not schools)	5
(d) Cemetery	1
2. Farm Problems—	
(a) Farmsteads	9
3. Suburban Properties	8
Total	33

Besides the plans made several talks were given before various sorts of farmer's organizations and civic improvement clubs.

It is hoped that funds will be available from the extension division to place a man on full extension time during the coming year, as this department, otherwise, will not be able to take care of the demand for this work which is becoming more pressing each year, and a refusal of help on requests tends to develop an antagonistic feeling toward the institution. It would seem if we are interested in making country life more worth while, that we should be anxious to encourage a greater interest in the development of rural home grounds, and in the aesthetic development of all other rural grounds such as of the consolidated school grounds, rural town parks, rural cemeteries, and such other public properties in our rural communities as will tend to make them more beautiful and satisfactory.

Respectfully yours,
C. P. HALLIGAN,
Professor of Landscape Architecture.

FIRST REPORT OF THE LIBERAL ARTS COUNCIL

To the President:

Sir:—Members of the Board of Control for the current year:

W. W. Johnston,
C. P. Halligan,
W. H. French.

Student members:

C. L. Richards,
E. C. Perrine,
Ruth Chamberlin,
Frances Holden.

We feel that the Liberal Arts Council has provided wholesome literary and musical entertainment for the student body in the form of five (5) lectures, one dramatic reading, and three (3) musicals as listed below:

October 24, Douglas Malloch	$100.00
November 22, Carl Sandberg	150.00
December 5, Marie Tiffany	250.00
January 9, Theo Carle	350.00
January 24, Henry L. Southwick	100.00
February 6, Elschuco Quartet	400.00
March 13, Louis K. Anspacher	150.00
April 10, M. A. C. Glee Club	100.00

In addition to the foregoing items of expense, there have been bills for printing, labor and supplies.

The entire financial statement for the year showing receipts and expenditures, is appended hereto.

The Council desires to repeat the recommendation of one year ago, that the President shall call a joint meeting of the special entertainment committees of the college, in order that a schedule may be arranged so that there may be the fewest possible conflicting dates. There are so many activities on the campus that it is difficult to find open dates for our entertainments. We also ask that permission be given us to use the gymnasium for an auditorium for the ensuing year.

Respectfully submitted,
W. H. FRENCH,
Chairman Liberal Arts Council.

RECEIPTS AND DISBURSEMENTS.

Committee on Liberal Arts, School Year 1922-1923.

Receipts—	
June 30, 1922—Balance on hand	$430.22
June 30, 1923—Student fees	1,419.35
Gate receipts	234.50
	$2,084.07
Disbursements—	
June 30, 1923—Refund to students	$5.96
Labor	135.15
Entertainments	1,750.00
Printing	47.60
Music	48.00
Miscellaneous	17.07
Balance on hand	80.29
	$2,084.07

W. H. FRENCH,
Chairman and Secretary, Liberal Arts Council.

FIRST REPORT OF THE BOARD IN CONTROL OF ATHLETICS.

To the President:

Sir:—In accordance with section "G" of a motion of February 2, 1923, of the State Board of Agriculture, establishing the Board in Control of Athletics, the following report "of the business and condition of the athletic department" for the college year 1922-23 is herewith submitted.

The Board in Control of Athletics has found it necessary to organize the department of physical education according to its convictions concerning the policies to be pursued and the distribution of duties among the various members of the department. A director of athletics, Ralph H. Young, will take charge of the department September 1, and will carry out a constructive program which will uphold the standards of athletics for which M. A. C. has long been noted. All changes in personnel and policy have been made with the hope and belief that they will bring about a period of thorough development within the department so that it may do its share to aid the progress of the college.

In equipment, the board can report the completion of plans for an adequate athletic field including facilities which have long been lacking. This field will be situated south of the Red Cedar as close as possible to the gymnasium. Its most important unit, the stadium, is nearing completion and will be ready for football games this fall. Tennis courts, baseball diamonds and other fields will be provided as the need arises.

In its financial standing the department has prospered during the past year in spite of a reduction in income from the college. For the year 1921-22 your board appropriated for this department a total of $24,400 of which $3,200 was for general expenses and the balance for salaries. In addition to this amount the department had for its use about $1,400 in fees from the gymnasium lockers. The following year, 1922-23, the appropriation was reduced to $22,000, $2,000 of which was for general expenses and the locker fees were turned into the general college fund, and at the beginning of that year there was a deficit in loans and unpaid bills of $12,047 on the books of the department. A closely applied policy of economy makes it possible to report the department books now carrying but $3,400 in loans and about $1,000 in unpaid bills, a net gain of about $7,600 over the previous year.

On the salary roll of the department in 1922-23 there were seven men on full-time contracts, one on part time, three women on full-time and a clerk, an aggregate roll of $29,280. On the list for 1923-24 there will be five men on full-time contracts, one on part-time, two women on full-time and one clerk at a total of $26,680, including $500 to R. H. Rauch which should have been paid last year, and $1,200 to A. M. Barron in settlement on his contract. This shows a net reduction in salaries for next year of $4,800.

Included in the expenses of the department for the past year is $1,738.77 used in direct advertising for the college. The interscholastic basketball and track tournaments of the past year brought about 1,000 high school students to the college. These gatherings give the institution an unparalleled opportunity to impress upon the vistors the desirability of attending M. A. C. and many will enroll this fall as a result.

In installing the course in physical education which your board has approved as a regular part of the curriculum, the board hopes that the college will be better equipped to serve its purpose as an educational institution by preparing men and women for positions as instructors of physical training in the schools of the state.

The department of physical education is going into the new year with a smaller appropriation from the college, a reduced, but what is designed to be, a more efficient staff, a smaller indebtedness than the previous year and the best equipment M. A. C. has ever had. This board is putting forth its best efforts to insure for M. A. C. the prestige on the athletic field to which her standing in the collegiate world entitles her. It is building firmly so that the victories of her teams will be the result of irreproachable tactics and that the department of physical education may exist for the benefit of the entire student body as well as for the comparative few who make up the different squads.

Detailed financial statements for that part of the college year previous to the time this board took office and for the five months ensuing are attached.

RALPH C. HUSTON,
Chairman.
ROBERT J. McCARTHY,
Secretary.

FINANCIAL STATEMENT.

Michigan Agricultural College Athletic Association, July 1, 1922, to February 1, 1923.

RECEIPTS

Football	$24,055.42		
Basketball	1,337.81		
Cross-country	106.10		
Student fees	13,807.06		
Equipment and supplies	479.77		
Training table	2,183.88		
Miscellaneous	4,230.39		
Total		$46,200.43	
Total receipts			$46,200.43

DISBURSEMENTS

Football	$15,759.52		
Basketball	2,122.66		
Cross-country	746.36		
Swimming	127.80		
Salaries	1,649.00		
Student labor	241.80		
Student refund	138.20		
Equipment and supplies	5,228.46		
Advertising and printing	884.37		
Services, professional	454.50		
Training table	4,941.93		
Telephone and telegraph	200.90		
Miscellaneous	7,377.34		
Total disbursements		$39,872.84	
Balance on hand February 1, 1923		6,327.59	
			$46,200.43

FINANCIAL STATEMENT,

Michigan Agricultural College Athletic Association, February 1, 1923, to July 1, 1923.

Balance on hand February 1, 1923		$6,327.59	
Receipts—			
Basketball	$1,063.10		
Baseball	1,600.65		
Track	950.00		
Wrestling	635.05		
Swimming	250.00		
Interscholastic basketball	355.00		
Interscholastic track	96.70		
Intercollegiate track	56.50		
Student fees	7,127.04		
Supplies and equipment	1,416.61		
Training table	1,260.40		
Miscellaneous	3,633.82		
Total receipts		$18,444.87	
			$24,772.46

Disbursements—			
Basketball	$1,767.03		
Baseball	2,713.44		
Track	1,861.92		
Tennis	245.16		
Wrestling	804.87		
Swimming	458.50		
Interscholastic basketball	503.93		
Interscholastic track	379.89		
Intercollegiate track	226.31		
Salaries	7,523.35		
Student labor	512.14		
Supplies and equipment	3,505.37		
Printing and advertising	726.34		
Professional services	225.00		
Training table	2,390.52		
Telephone and telegraph	124.30		
Student refund	122.49		
Miscellaneous	277.47		
Total disbursements		$24,368.03	
Balance on hand July 1, 1923		404.43	
			$24,772.46

FINANCIAL STATEMENT,

Michigan Agricultural College Athletic Association, July 1, 1922, to July 1, 1923.

Receipts—			
Football	$24,055.42		
Basketball	2,400.91		
Baseball	1,600.65		
Track	950.00		
Cross-country	106.10		
Wrestling	635.05		
Swimming	250.00		
Interscholastic basketball	355.00		
Interscholastic track	96.70		
Intercollegiate track	56.50		
Student fees	20,934.10		
Supplies and equipment	1,896.38		
Training table	3,444.28		
Miscellaneous	7,864.21		
Total receipts		$64,645.30	
			$64,645.30
Disbursements—			
Football	$15,759.52		
Basketball	3,889.69		
Baseball	2,713.44		
Track	1,861.92		
Cross-country	746.36		
Tennis	245.16		
Wrestling	804.87		
Swimming	586.30		
Interscholastic basketball	503.93		
Interscholastic track	379.89		
Intercollegiate track	226.31		
Salaries	9,172.35		
Student labor	753.94		
Supplies and equipment	8,733.83		
Printing and advertising	1,610.71		
Professional services	679.50		
Training table	7,332.45		
Telephone and telegraph	325.20		
Student refund	260.69		
Miscellaneous	7,654.81		
Total disbursements		$62,240.87	
Balance on hand July 1, 1923		404.43	
			$64,645.30

REPORT OF THE M. A. C. ASSOCIATION.

To the President:

Sir:—Upon taking over this office in August, 1922, I was informed by the executive committee of the M. A. C. Association that an appropriation of $4,500 had been made for the use of this Association and that an agreement had been entered into between the members of our executive committee and the State Board that, should the expenses of the office total more than the appropriation, the Board would appropriate enough more to make up the deficit. I have the pleasure to report that the office was run within the appropriation during the past year, in spite of the fact that only $4,500 was appropriated, while during the previous year $6,300 had been set aside for our use.

I should like to bring to the attention of the Board several unusual conditions which have affected the conduct of the office during the past year:

> There was no regular secretary from January 1, 1922, until August 1, 1922. As a result the Association paid an acting secretary $100 from its funds for special work at commencement time. This lack of a directing head also found the office seriously lacking in equipment and supplies and, as a result, a comparatively large sum was spent on this account during the past year.
>
> The college did not see fit to send out invitations to the alumni to return for commencement so this office assumed the responsibility and the expense of the undertaking both at that time and at Homecoming in the fall. On both occasions the results were gratifying and of considerable benefit to the college in alumni interest and the influence these affairs have on the general public.
>
> This spring the college ceased paying the telephone bills of the office and this expense was added to the former burden of the office, subtracting that amount from the gross appropriation, which had been greatly reduced from the previous year.
>
> Requisitions from this office were not honored by the college purchasing agent after July 1, 1922, except those signed by the secretary of your Board, which in all cases were paid from our funds.
>
> The secretary of the Association is also engaged as director of the campaign for the Union Memorial Building Fund. This is the only known case where a special director was not engaged by the college or detailed from the college payroll for such a purpose.
>
> Appliances used in the office have decreased the expenditure for student labor by a large amount over previous years, and a new arrangement for addressing The Record has also aided greatly in this respect.
>
> This office has been active in advertising the advantages of the college. An issue of The Record in May was financed by the East Lansing business men and 3,000 copies were distributed through the alumni to prospective students among the senior classes of the

> high schools. This office collected a list of 1,000 names of prospective students through alumni employed as high school teachers.
>
> This office has also, through a system of sending two sample copies of The Record each year to all former students, kept many in touch with the college who have no other means of knowing its progress and the increasing opportunities it offers to students. This has only been done at considerable expense which has been charged to The Record and paid from its funds.
>
> The Record is one of the very few alumni publications which do not carry paid advertisements of the college.
>
> But one clerk is employed regularly in the alumni office and all clerical work in connection with the M. A. C. Union, the regular alumni work, and that of the Board in Control of Athletics is handled through this office. Another is employed on part-time to handle the affairs of the Union Memorial Building campaign and funds but her salary is paid from that fund. All equipment especially purchased for the Union Memorial Building campaign is paid for from that fund and supplies for that special purpose, including postage, also come from that source.

The Association appreciates the support of the State Board of Agriculture while it is establishing itself upon a firm business basis. It believes that, to be truly helpful, it should be entirely self-supporting and is planning its program to the end that within a few years it hopes to be able to conduct its affairs without an appropriation from your Board.

All of the efforts of this Association are turned toward aiding the program for a larger, more efficient M. A. C. Through close organization of the alumni it is certain that they will be better able to benefit the institution. The Association is always ready to aid in any program looking toward the betterment of the college; it is anxious to lend its strength to such movements as will forward the aims of M. A. C. Your help in building this organization will result in lasting benefit.

A financial statement showing the disposition of the $4,500 appropriated for this office by your Board for the fiscal year 1922-23 is attached. Your appropriation of a similar amount for 1923-24 will enable us to carry on our work but will not allow us to expand our program.

Respectfully submitted,
ROBERT J. McCARTHY,
Secretary.

FINANCIAL STATEMENT

Of the M. A. C. Association from July 1, 1922, to July 1, 1923.

Received from College	$4,500.00	
Disbursements—		
Salaries	$1,365.00	
Office supplies	550.48	
Commencement, 1922	66.64	
Commencement, 1923	141.50	
Telephones and telegrams	44.16	
Student labor	37.18	
Traveling expense	45.73	
Homecoming expense	46.70	
Insurance	9.75	
Stamps and envelopes	327.85	
Salary of Secretary	1,865.01	
Total disbursements		$4,500.00

REPORT OF THE SECRETARY AND TREASURER.

The following shows the Receipts and Disbursements of the Experiment Station for the year ending June 30, 1923.

		Dr.	Cr.
July 1, 1922.	To balance overdrawn		$107,967 26
Aug. 26, 1922.	received from U. S. Treasury	$7,500 00	
Oct. 22, 1922.	received from U. S. Treasury	7,500 00	
Jan. 10, 1923.	received from U. S. Treasury	7,500 00	
Apr. 20, 1923.	received from U. S. Treasury	7,500 00	
June 33, 1923.	State Treasurer, one-fifth mill fund	180,000 00	
	Graham Horticultural Experiment Station	852 24	
	Upper Peninsula Experiment Station	5,581 32	
	South Haven Experiment Station	629 94	
	Miscellaneous	4,442 24	
	By disbursements as per vouchers filed in office of the State Auditor General		240,849 86
	Inter-department transfer	872.65	5,188 35
	Balance overdue	131,627 08	
Total		$354,005 47	$354,005 47

Forty thousand special bulletins No. 117; thirty-five thousand special bulletins No. 118; thirty thousand special bulletins No. 121; twenty-three thousand circular bulletins No. 49; twenty-five thousand circular bulletins No. 50; ten thousand circular bulletins No. 51; ten thousand circular bulletins No. 52; fifty thousand circular bulletins No. 53; eight thousand circular bulletins No. 54; nine thousand circular bulletins No. 55; nine thousand circular bulletins No. 56; nine thousand circular bulletins No. 57; nine thousand circular bulletins No. 58; nine thousand circular bulletins No. 59; nine thousand circular bulletins No. 60; four thousand technical bulletins No. 55; four thousand five hundred technical bulletins No. 56; four thousand five hundred technical bulletins No. 57; four thousand five hundred technical bulletins No. 58; and Quarterly Volumes Nos. 1, 2, 3, 4, and 5 have been issued by the Experiment Station during the fiscal year.

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.

	Hatch Fund	Adams Fund
Salaries:		
Director and other administrative officers	$1,817 60	
Scientific staff	2,681 60	
Assistants to scientific staff	10,449 80	$15,000 00
Totals	$15,000 00	$15,000 00

DISBURSEMENT OF EXPERIMENT STATION MONEYS—OTHER THAN RECEIVED FROM U. S. TREASURER.

Salaries	$108,453	60
Labor	43,635	58
Publications	10,780	05
Postage and stationery	1,400	07
Freight and express	793	88
Heat, light, water and power	3,028	91
Chemicals and laboratory supplies	3,422	81
Seeds, plants and sundry supplies	10,571	48
Fertilizers	1,592	53
Feeding stuffs	5,581	38
Library	1,313	83
Tools, machinery and appliances	4,150	33
Furniture and fixtures	387	80
Scientific apparatus and specimens	1,817	26
Live stock	2,721	40
Traveling expenses	13,816	88
Buildings and land	2,570	42
Total	$216,038	21

THIRTY-FOURTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

OF THE

Michigan Agricultural College

UNDER THE STATE HATCH AND ADAMS ACTS

FOR THE

YEAR ENDING JUNE 30, 1923.

For members and organization of the State Board of Agriculture in Charge of the Station and list of officers, see pages – and — in this volume

REPORT OF THE DIRECTOR OF EXPERIMENT STATION.

To the President:

Sir:—Accompanying this report are the individual reports of the various sections of the Experiment Station. While these reports are quite complete, I wish to direct your attention to some of the especially interesting phases of work in the various sections.

This year completes the three-year project by the Animal Husbandry Section on "Stover Silage Versus Normal Silage for Fattening Steers." Very interesting results have been secured on that project as well as on the project on "Comparative Value of Michigan Grains for Swine Feeding."

The U. S. D. A. Sugar Beet Station for the humid area was transferred on April 1, from Blissfield to the Farm Crops Section of this institution. One of the clover stations of the U. S. D. A. is also now located at the Michigan Station. The plant breeding and cultural projects have continued to be as valuable this year as during the previous years. Southern European strains of clover seed were found to be inferior to Michigan Red clover. The Chemistry Section is co-operating with the Farm Crops Section in their project "Michigan Wheats and Flours."

The work of the Soils Section on the use of lime and fertilizers is proving to be more valuable each year. The development of the Soiltex Soil Reaction Test by Spurway is one of the outstanding developments of the year. The soil survey work has also progressed satisfactorily.

The Dairy Section has started some very careful and complete nutrition projects. Some feeding and forage tests have also been completed this year. Important results have been secured along the line of research in dairy manufacture.

The spraying, dusting, and fertilizing projects of the Horticultural Section have been conducted with renewed vigor. Cultural and breeding work have been carried on with small fruits and vegetables. The South Haven peach, a new variety developed at the South Haven Station, gives promise of filling a long-felt need of the peach grower.

The Farm Mechanics Section has made notable progress in the development of their marl excavation outfit as well as a home-made lime spreader. The work of the Forestry Section in the study of "Second Growth Hardwoods In Cut-Over Lands" as well as other projects gives promise of considerable value.

The work of the Entomological Section in aiding in the control of coddling moth, grapeberry moth, and chinch bug has been very satisfactory. Dr. Chandler with his new vermifuge has been quite successful in the control of intestinal parasites of the silver fox.

Special progress of the work in poultry diseases and contagious abortion is recorded by the Bacteriological and Pathological Sections. Cooledge's colorimetric hydrogen-ion method of determining the keeping quality of dairy products has this year proved to be a very valuable means of checking up on faulty dairy practices. Special work in the diseases of potatoes, sugar beets, and cereals has been conducted by the Pathological division of the Botanical Section. Work in plant nutrition has also been conducted.

Marked progress is reported in the land clearing work at the Upper Peninsula Station at Chatham. Special investigations have been carried on relative to costs and methods of plowing and breaking cut-over land on the Station farm. The crops and livestock work of the Station have been managed as before.

Substantial support was given the Station during the year through supplementary state aid granted by the State Board of Agriculture from current funds of the College. There are now over one hundred and eighty investigational projects in progress. The following statement includes receipts and disbursements of the Station for this year:

Receipts

State Appropriation	$214,027.72
Sales	9,505.74
Hatch Fund	15,000.00
Adams Fund	15,000.00
	$243,533.46

Disbursements

Main Station	195,149.80
U. P. Station	26,830.56
Graham Station	7,249.27
South Haven Station	4,303.83
Soil Survey	10,000.00
	$243,533.46

The following is a list of the Station bulletins issued during the year:

Specials

117 Potato Culture	40,000 issue
118 Pruning of Fruit Trees	35,000 issue
76 Transferring Bees (Reprint)	7,000 issue

Quarterlies

Vol. 5 No. 1, August, 1922	45,000 issue
Vol. 5 No. 2, November, 1922	45,000 issue
Vol. 5 No. 3, February, 1923	45,000 issue
Vol. 6 No. 4, May, 1923	45,000 issue

Circulars

48 Spraying for Hopperburn	12,000 issue
49 Hessian Fly	23,000 issue
50 Hairy Vetch	25,000 issue
51 Chinch Bug	10,000 issue
52 The Grape-berry Moth in 1922	10,000 issue
53 Standard Fertilizers for Michigan	50,000 issue
54 Lime for Van Buren County Soils	9,000 issue
55 Lime for St. Joseph County Soils	9,000 issue
56 Lime for Cass County Soils	9,000 issue

57 Lime for Calhoun County Soils	9,000 issue
58 Lime for Berrien County Soils	9,000 issue
59 Lime for Ottawa County Soils	9,000 issue
60 Lime for Kalamazoo County Soils	9,000 issue
Poultry	
52 Issues of Press Bulletins—Weekly Reports of Egg Laying Contest.	
Technicals	
57 Studies on Active Bases and Excess Acids In Mineral Soils	4,500 issue
58 The Occurrence of Protozoa in Plants affected with Mosaic and related diseases	4,500 issue
59 Flat Sours	4,500 issue
60 The Influence of Manufacturing Operation On the Bacterial Content of Ice Cream	4,500 issue

Respectfully submitted,
E. B. HILL,
Assistant to the Director of Experiment Station.

REPORT OF THE SECTION OF ANIMAL HUSBANDRY.

To the Director:

Sir:—I have the honor to submit the following report of the experimental work conducted by the Animal Husbandry Section during the year ending June 30, 1923.

A third test with normal silage fed to Lot I, stover silage fed to Lot II and stover silage plus the corn which was removed at the time of ensiloing returned to the ration, to Lot III.

The average results of the three tests are as follows:

	Lot I	Lot II	Lot III
Average Initial Weight	843.5	843.5	848.9
Average Final Weight	1,206.2	1,106.0	1,141.3
Average Gain per Steer	362.6	262.5	292.4
Average Daily Gain	2.35	1.70	1.90
Average Daily Ration:			
Normal Silage	42.66	....	....
Stover Silage	....	43.15	40.91
Protein Supplement	2.34	2.34	2.34
Shelled Corn	5.05	5.73	8.74
Clover Hay	2.82	3.10	3.10
Feed Consumed per pound of gain:			
Normal Silage	18.12		
Stover Silage	....	25.31	21.55
Protein Supplement	.995	1.374	1.234
Shelled Corn	2.146	3.36	4.6
Clover Hay	1.19	1.81	1.63
Cost per Cwt. Gain (not crediting pork produced)	8.996	9.90	10.47
Cost per Cwt. gain (Crediting pork produced)	8.21	9.25	9.56

The result of each trial was very much the same as the average of the three trials. Lot I in each trial gained more rapidly, made cheaper gains, took on more finish and sold at a higher price per pound than either Lot II or Lot III. While Lot III in each trial gained more rapidly than Lot II, they were not considered to be worth any more by the buyers. The dressing percentage in each case showed that Lot III was better finished and worth more than Lot II.

In the 1922 report attention was called to the fact that pigs, fed the commonly grown farm grains in connection with tankage as a protein supplement, all feeds being fed free choice, did not properly balance their own rations.

One series of trials using the same feeds as were used previously, but combining them according to accepted standards and feeding the mixed ration in the self-feeder have been completed. The results have been as follows:

	Corn	Barley	Rye	Middlings	Tankage	Total	Average Daily Gain
Lot I—Free Choice....................	239	53.5	1.39	....	30.5	462	1.391
Lot IA—Mixed Ration.................	124.3	124.3	124.3	....	31.9	404.8	1.43
Lot II—Free Choice..................	....	....	414	....	42	456	1.151
Lot IIA—Mixed Ration................	....	....	440.8	....	24.6	465.4	1.047
Lot III—Free Choice..................	....	444	....	....	28	472	1.301
Lot IIIA—Mixed Ration...............	....	364.2	....	....	25.6	389.8	1.557
Lot IV—Free Choice..................	395	....	....	....	40	435	1.472
Lot IVA—Mixed Ration................	337.7	....	....	....	43.5	381.2	1.57
Lot V—Free Choice....................	......	257	178	....	32	467	1.21
Lot VA—Mixed Ration..................	....	180.1	180.1	....	30.8	391	1.39
Lot VI—Free Choice..................	....	269	....	157.7	26.6	453.3	1.17
Lot VIA—Mixed Ration................	....	284.9	....	106.8	12.1	403.8	1.437
Lot VII—Free Choice.................	....	....	195.	226	26	447	1.12
Lot VIIA—Mixed Ration...............	....	....	295.6	110.8	8.3	414	1.16

With the exception of Lot IIA, all lots receiving the mixed ration made larger daily gains and required less feed per 100 pounds gain. The results of this one test show marked results in favor of the prepared ration over the free choice system. Definite conclusions should not be drawn until two more tests have been completed.

Many inquiries have been received relative to the value of powdered skim milk as a feed for pigs. To answer this question, Mr. C. D. Christoulias, a graduate student in 1922, conducted a trial with three Lots of pigs, with the following results:

	Lot I 5 Pigs Corn and Tankage	Lot II 5 Pigs Corn and Powdered Skim Milk	Lot III 5 Pigs Corn and Skim Milk
Initial weight per pen	382	376	375
Final weight per pen	1001.8	1088	1126
Total gain per pen	619.8	712	751
Average gain per pig	120	142.4	152.2
Average daily gain per pig	1.36	1.56	1.65
Average daily ration:			
Corn	4.42	4.52	4.42
Tankage	.647		
Powdered Skim milk		.903	
Skim milk			10.12
Feed per 100 lbs. gain:			
Corn	324.7	288.3	268.3
Tankage	47.4		
Powdered skim milk		57.7	
Skim milk			613.3
Total	372.1	346.0	881.6

The corn used in the above test cost $0.62 per bushel and the tankage $60.00 per ton. Using these two feeds fed Lot I as a basis for comparison, the 57.7 lbs. of powdered skim milk fed Lot II replaced 47.4 lbs. of tankage worth $1.42 and 36.4 lbs. corn worth $0.40, making 57.7 lbs. of powdered skim milk worth $1.82, or a hundred pounds of powdered skim milk was worth $3.16.

The 613.3 lbs. of skim milk fed to Lot III replaced 47.4 lbs. tankage worth $1.42 and 56.4 lbs. of corn worth $0.62, making 613.3 lbs. skim milk worth $2.04, or one hundred pounds of skim milk was worth $0.33.

Very truly yours,
GEO. A. BROWN,
Professor of Animal Husbandry.

REPORT OF THE SECTION OF DAIRY HUSBANDRY.

To the Director:

Sir:—

INVESTIGATION AND TEACHING.

The investigation work has been increased immeasurably since the appointment of Mr. C. F. Huffman and the half and quarter-time assistants. A new experimental shed has been erected and equipped for carrying on special work with growing animals. The principal experiment with growing animals has been along the line of determining the feeding value of several mineral feeds as a supplement to ordinary rations and to study their effect upon the general health, growth, reproduction, and milk production. Five lots of calves of five animals each are being used in this work and are being fed various commercial mixes in addition to home made mineral mixes. The work put out along this line is progressing very nicely, but has not gone far enough to draw any conclusions.

Another project is "The Minimum Crúde Fiber in Ration of Ruminants." This experiment is well under way and promises to give us new information along this line.

Studies are also being made as to the effect of acid ash rations as compared to basic ash rations on the growth and development of calves. Two lots of calves are being used in this work.

Field experiments in which data are being gathered from a number of herds in the vicinity of Lansing, are being carried on to determine the normal alkaline reserve of the blood of dairy cattle under ordinary farm conditions. Any information gathered from this source will be extremely valuable in studying the results of the alkaline reserve of the animals used in the experiments listed above.

The effect of low calcium in the ration of dairy heifers on growth, health, and reproduction is being studied.

Experiments are being carried on to determine the relative vitamine content of silage made from green corn stover and that made from dry stover.

Studies have been made to determine the effect of calving, exercise, lactation, dry period, and the effect of feeding colostrum milk, calcium carbonate, bone meal, silage, and straw on the alkaline reserve of the blood of dairy cattle.

An experiment has been conducted during the past winter season which is the first of a series of trials in feeding cull beans to dairy cows and comparing them with cottonseed meal. There are a great many cull beans available for feed in the State and there has been considerable demand for information along this line. In this study the amount of cull beans that can be substituted for cottonseed meal will be determined and the effect of them upon the animal's appetite and general behavior. The first of these series has been completed and will be ready to publish before the winter season begins.

Pasture experiments with sweet clover and other grasses are being carried on as outlined last year.

Studies are being made relative to the normal temperature of cattle. The temperature of each animal in the herd is taken daily. Weights and measurements are also being taken of all animals in the herd every six months and all animals under freshening age every month.

Investigation has been started to determine the relative efficiency of clarification of milk as compared with filtering milk in distributing plants.

Reports have been made on two experiments conducted by Professor P. S. Lucas and the results have been published in the trade papers. The first one has to do with the use of aniline dye for coloring glymol to be used in reading cream tests made by the Babcock method. Following is a statement of how this dye is used:

Alkanet root, which has for a considerable time been used for coloring the glymol used for reading cream tests, has three objections: the time required for it to dissolve, the sediment that occurs after the solution and the fact that it is easily decolorized by exposure to light. An aniline dye, oil soluble, which this Station has found suitable for coloring glymol, is Newport Oil Red 3 BS. This is a very inexpensive dye, costing 50c an ounce. One ounce will color 25 gallons of oil. This dye is manufactured by the Newport Chemical Works, Passaic, New Jersey. It has at the present time been discontinued, and Newport Oil Red No. 13044 is offered in its stead. One ounce of the latter will color between 40 and 45 gallons of glymol. Other colors, such as green and blue, were tried. It is very difficult to get a brilliant green color and the contrast between the yellow of the fat column is entirely unsatisfactory. The use of aniline dye is approximately 500 per cent cheaper than the use of alkanet root. It requires but five minutes for the material to be put into solution. It is best mixed up as a paste with the oil and if possible, slightly heated. It has no greater tendency to mix with the butterfat than the alkanet colored oil and it is not decolorized by being exposed to the air.

During the past year sugar prices have soared and it has been necessary for the ice cream trade to use sugar substitutes. Since there was no data available on this subject giving the information as to what substitutes to use and as to how they should be used, an experiment was conducted and the following sources of sugar and the amounts to use were determined, and they have been used quite generally by the ice cream trade. The figures given here of the various sweetening agencies are equivalent to the sweetening value of one pound of sugar.

Glucose	3.26 pounds
Honey	1.74 pounds
Maple Sirup	1.51 pounds
Corn Sugar	1.59 pounds
Karo Sirup	2.46 pounds
Invert Sugar Sirup	1.38 pounds

Figuring cane sugar at 10c per pound, glucose at 4c, honey at 18c, maple sirup at 25c, corn sugar at 6.7c, Karo sirup at 5c, invert sugar sirup at 7.1c, the cost of each respectively to be equivalent to one pound of sugar, is as follows: 13.40, 31.23, 37.75, 10.55, 12.3, and 9.78. While in every case costing more, these materials do supply a high per cent of the total solids when given in terms of cane sugar equivalent. The following average total solids was found: cane sugar, 94.85; glucose, 82.13; honey, 81.56; maple sirup, 68.04; corn sugar, 93.65; Karo sirup, 76.01; invert sugar sirup, 66.12.

Cane sugar and invert sugar sirup give tastes very much alike. Honey and maple sirup are impractical because of their cost. Honey gives a flavor which if used in large amounts becomes tiresome to the consumer. Corn sugar probably offers the greatest possibilities as a sugar substitute, but at the present prices it is not as economical as cane sugar.

During the past year a total of 963 students have received instruction throughout the year. This includes both long and short course students. There were 621 short course and 342 long course students. Special short courses for the field men of the creamery manufacturing and milk distributing plants were offered again this year, as well as special courses in market milk and ice cream work. These courses were fairly satisfactory and the ice cream course particularly was in great demand. The short course in dairy production was changed during the past year from an eight weeks' to a 12 weeks' course and the feeling of the members of the Department as well as the men who took the course was that this was a decided change for the better. A more complete course was given and the students who came here for that work were able to get almost double the training that they formerly got in the eight weeks. This course will be continued on the 12 weeks' basis.

The institution was again represented at the student judging contest at the National Dairy Show. The team consisted of Lynn Heatley, Waino Helli, and Paul Barrett, and made a very creditable record. Along with the 22 institutions entered, the team from this institution lined up eighth.

As stated in last year's report the college creamery was put on a commercial basis in the fall of 1921. This change was made in order that our students should get better instruction in a real commercial concern and particularly for our short course students to get training under actual operating conditions since they are here only a very short time. The creamery has had a very successful year from a financial standpoint, and our make of dariy products has greatly increased. The total amount of butter made was 157,808 pounds; ice cream, 5,209 gallons; and 23,666 pounds of cottage cheese; 1,079,122 pounds of milk were delivered. The retail milk route which has been operating for some time is being continued. Pasteurized milk and raw milk from the college dairy have been sold. This business is now on a sufficiently large scale to make it profitable to operate and at the same time give our students the very best instruction possible.

Respectfully submitted,
O. E. REED,
Professor of Dairy Husbandry.

REPORT OF THE SECTION OF ANIMAL PATHOLOGY.

To the Director:

Sir:—I herewith submit the annual report of the pathologist for the year ending June 30, 1923.

We have continued the investigations of disease of the reproductive organs of cattle. There are four subdivisions of this project that are being investigated, namely: the bacteriology and histo-pathology of the reproductive organs in sterility; the bacteriology and histo-pathology of the reproductive organs of calves and heifers from abortion infected herds; the bacteriology and histo-pathology of the reproductive organs of pregnant cattle from abortion infected herds; and, the bacteriology and histo-pathology of the uterus in evolution and involution.

We have nothing to add to what has already been published under the first subdivision of this project but the work will be continued.

In the second subdivision our results have been negative in so far as structural alterations of the reproductive organs are concerned. The number of cases studied, however, is not sufficient to justify any conclusions at this time. Under this head we are attempting to trace the avenue of invasion of abortion infection in experimentally inoculated heifers. This phase of the problem requires a great amount of routine examination but it is of considerable scientific interest and practical importance.

The greatest amount of time has been spent upon the third subdivision of this project. Our observations are very interesting but we are not sure yet that we are able to interpret them. Considerable time has been spent upon a method of staining both Gram negative and Gram positive organisms in sections from the reproductive organs of pregnant cattle, with considerable success.

The method is a combination of Goodpasturiz and the Weigert Fibrin stain. By this method we are able to demonstrate large numbers of cell inclusions in both the chorionic and maternal epithelium of the placental and interplacental areas. These inclusions are present in large numbers and resemble abortion bacilli. We find them in large numbers in positively reacting animals and also in negatively reacting animals, also in animals from which abortion bacilli are obtained by cultural or inoculation methods and in animals from which no micro-organisms are obtained by such methods. All cases studied so far have been from abortion infected herds.

In spite of their close resemblance to abortion bacilli we are not yet in a positoin to say that they are micro-organisms. Their presence is associated with well-marked granular degeneration and necrobiosis of the epithelium. Other than this, in those cases in which other forms, such as streptococci, stephylococci and larger rods cannot be found, there is but little evidence of tissue reaction. That is, there is no well-marked leucocytosis, inflammatory exudate (other than numerous placental hemmorrhages) nor tissue proliferation. In some cases where other forms of micro-organisms are observed in sections evidence of proliferation of the connective tissue leading to thickening of the walls of the crypts is observed. If this is a frequent condition, it would explain retention of the placental membrane. The Granular degeneration of the placental epithelium is so marked in some cases that one might suspect that it would influence the interchange of nutritive and metabolic products between dam and fetus. We have made some observations that lead us to suspect that this is the case although we are not ready to draw any conclusions.

In a few cases in which extensive granular degeneration of the placental epithelium is seen we have observed what we suspect as an attempt to bring about attachment of the chorion and maternal mucosa in the interplacental areas. Normally the general opinion is that there is no connection in the bovine, between the chorion and uterine mucosa in the inter carunculæ areas and that the maternal epithelium in these areas retains the adult type during pregnancy. We have observed changes in these areas that appear to us identical with those changes observed in the plancental areas. That is, in these areas, the maternal epithelium appears to have acquired the vegetative type, primary villi are seen to have grown out from the chorion and there is a corresponding outgrowth of the uterine mucosa, apparently the result or stimuli arising in the chorion. This condition has been observed before by other investigators in cases in which there has been loss of cotyledons at a previous parturition. We have observed this condition in cases in which neither the history nor the gross anatomical findings would indicate that its development was the result of loss of cotyledons at a previous parturition. The thought is suggested that it may develop as a result of the degenerative changes in the maternal and chorionic epithelium referred to above and may possibly be interpreted as nature's method of compensating for those changes in the epithelium that influence the interchange of nutritive and metobolic products between dam and fetus. This hypothesis, we believe, is justified by the observations already made but a great deal more investigational work must be done before conclusions may be drawn.

There is another condition observed that we are unable to explain. The extent of granular degeneration and necrobiosis of the chorionic and maternal epithelium is marked. Naturally, in this condition one would expect to find extensive denuded areas of the placenta. Such is not the case. We have attempted to explain this in our own mind by assuming that the vegetative type of epithelium found here possesses marked regenerative properties and that repair is very active. Whether this explanation is the correct one, further investigation only will determine.

In our studies of involution and evolution of the uterus we have observed many denuded areas of the maternal placenta in the evoluting uterus but we believe that a great deal of this is the result of phogocytic activity of the chorionic epithelium or the result of the action of the enzymes elaborated by the chorionic epithelium. We are inclined to believe that in the development of the maternal crypt, much of the maternal epithelium is destroyed and the crypt wall later becomes covered with regenerated epithelium. If this is true the condition would favor the entrance of bacteria that were in the uterus at the time of conception or that later gained entrance to the pregnant uterus, into the maternal tissues. In fact our observations on this problem lead us to believe that the changes in the placenta are continuously progressive up until approaching parturition and that eroded areas of maternal tissue may be found at any stage of pregnancy, such areas possibly favoring the invasion of the maternal tissues by bacteria already present or gaining entrance to the uterus at any stage of pregnancy.

At this time we wish to acknowledge the valuable assistance of Mr. I. F. Huddleson of the Department of Bacteriology who has made the bacteriological examination of the cases studied in these investigations.

Respectfully submitted,
E. T. HALLMAN,
Animal Pathologist.

REPORT OF THE SECTION OF BACTERIOLOGY.

To the Director:

Sir:—The experimental work for which we are responsible has been carried on during the past year without serious interference and with gratifying results. We regret the necessity to report that Research Assistant R. L. Tweed severed his connection with the Station May 1, 1923. Carrying considerable responsibility and working in diverse fields, he was an efficient, loyal and congenial associate. He accepted a position with the Gorgas Hospital, Tampico, Mexico. His various projects will be distributed amongst the men of the Section best fitted to undertake the added responsibilities. Research Associate Fabin will assume charge of the vinegar work and flax retting investigations; Research Associate Cooledge will look after the work on foods; Research Associate Ruehle will take over the work on intestinal bacteriology including the acidophilus cultures; and Research Associate Huddleson will add to his duties that covered by Adams project 1 a, "The effect of diseases in the cow on the milk," in so far as the project deals with abortion of cattle. Mr. Cooledge will study other phases of this problem.

Report of Research Assistant R. L. Tweed.

Under the project, "The effect of diseases of the cow upon the milk" (Adams 1 a) a paper has been submitted reporting the study of the significance of high cellular count of milk from *Bact. abortus* infected udders as compared with that of non-infceted udders. This is recommended as a Technical Bulletin.

Work upon the four remaining phases as reported last year has been continued.

Graduate Assistant D. E. Hasley has taken up an additional phase of the project in "A comparative study of the various methods for isolating *Bact. abortus*" under the direction of Mr. Huddleson.

Vinegar.

From July 1, 1922, to May 1, 1923, 218 requests for vinegar cultures were received, 266 yeast cultures were sent out, and 243 cultures of acetic bacteria, not including ten gallons of culture sent to a Michigan vinegar company for starting generators, and 53 lots of chemicals for making honey vinegar.

Requests for cultures were received from British Columbia, Ontario, Montana, Idaho, Washington, Arizona, Illinois, Missouri, Pennsylvania, Texas, Oklahoma, Minnesota, Iowa, California, Massachusetts, Ohio, Indiana, Kansas and Wisconsin.

There was an increase of 129 requests for cultures this year as compared with last year.

Forty-nine samples of vinegar have been analyzed and advice given with respect to analyses.

Table.

Sample No.	% Acetic Acid	% Alcohol by Weight	Sugar	Color	Flavor	Suggestions
281	2.5			Amber	Good	Ventilate and keep warm
282	2.5	5.4	+—	Amber	Bitter	Inoc. Bact. aceti, keep warm
283	2.7			Dark amber	Woody	Ventilate and keep warm
284	5.0			Dark amber	Woody	May standardize to 4%
285	5.6			Light Amber	Woody	May standardize to 4%
286	2.0			Light amber	Woody	Ventilate and keep warm
287	3.5			Light amber	Woody	Ventilate and keep warm
288	2.5	3.47	+	Cloudy	Bad	Ventilate and keep warm
289	2.0	1.75	+	Straw	Flat	Hold for home use
290	3.0		+	Straw	Clean acid	Keep warm and ventilate
291	2.8		+—	Amber		Inoc. bact. aceti, keep warm
292	.6		None	Cloudy		N. G.
293	1.0	1.36	+—	Straw	Watery	N. G.
294	5.0			Dark amber	Clean acid	May standardize to 4%
295	5.5			Dark amber	Clean acid	May standardize to 4%
296	3.0		None	Amber	O. K.	Ventilate and keep warm
297	3.5		None	Amber	O. K.	Ventilate and keep warm
298	3.1	Too small		Light amber	Clean	Ventilate and keep warm
299	3.8		None	Light amber	O. K.	Ventilate and keep warm
300	5.3		None	Amber	O. K.	Market standard
301	2.2		+—	Light amber	Acid	Use for standardizing
302	3.0	+—	+	Light Amber	Acid	Inoc. Bact. aceti, keep warm
303	.9		None	Light amber	Acid	Use for standardizing
304	.8	2.35	+—	Amber	Bitter	Inoc. bact aceti for home use
305	1.9	1.20	++	Light amber	Watery	Inoc. bact. aceti for home use
306	2.3	.61	++	Light amber	Acid	Keep warm and ventilate for home use
307	1.4	1.29	None	Light amber	Watery	Hold in warm place; use for standardizing
308	2.1	1.67	++	Amber	Normal	Ventilate and keep warm; for home use
309	4.5		++	Cloudy	Normal	Market standard
310	1.4	.05	+	Cloudy	Watery	N. G.
311	0.9	.09	+++	Cloudy white	Weak	Inoc. with yeast
312	0.8	.67	++	Cloudy white	Weak	Inoc. with yeast
313	0.7	.31	++	Cloudy white	Weak	Inoc. with yeast
314	0.4	.14	++	White	Oily	Inoc. with yeast
315	3.2	.01	+	Amber	Normal	Ventilate; keep warm; for home use
316	0.5	.14	None	White	Bitter	N. G.
317	3.5		+—	Amber	Normal	Ventilate and keep warm
318	0.4	2.38	+	Amber	Bitter	Inoc. Bact. aceti; for home use
319		3.4	None	Amber	Alcoholic	Inoc. Bact. aceti

Table.

Sample No.	% Acetic Acid	% Alcohol by Weight	Sugar	Color	Flavor	Suggestions
320	0.7	0.15	+++	Light amber....	Weak........	Inoc. with yeast
321	1.5	0.78	Trace	Amber.........	Weak........	Use for standardizing
322	2.3	0.12	+	Amber.........	Normal......	Use for standardizing
323	2.3	0.38	+	Amber.........	Normal......	Use for standardizing
324	3.4	1.84	+—	Amber.........	Normal......	Ventilate and keep warm
325	3.0	1.52	+—	Amber.........	Normal......	Ventilate and keep warm
326	0.4	2.2	None	Light amber....	Alcoholic.....	Inoc. Bact. aceti; for home use
327	0.8	7.8	None	Amber.........	Normal......	Inoc. Bact. aceti
328	0.6	7.05	None	Light amber....	Normal......	Inoc. Bact. aceti
329	2.2	3.4	None	Light amber....	Normal......	Ventilate and keep warm

Food. Silage Poisoning.

Seven samples of silage, two of bran, two of oats and one of oat straw were received for analysis. All samples were suspected of causing forage poisoning. With the exception of one sample of bran and one of oats nothing was found to indicate that poisoning was due to toxin production. The one sample of bran and one of oats were each found capable of producing a toxin in peptic digest broth sufficiently toxic to kill a guinea pig in 12 hours with symptoms resembling those of botulism. As the laboratory did not possess botulinus anti-toxin at this time, a positive diagnosis of botulism could not be made. However, cultural and morphological characteristics resembled those of *B. botulinus* poisoning.

The table below gives data on food samples analyzed during the past year.

Table.

Food	Condition on receipt	Method of Canning	Organisms present	Recommendations
Brussels Sprouts...	Good..............	Cold pack....	None......................	None
Mixed vegetable...	Springer............	Commercially canned	Spore-forming rod. Thermophile.	Discard all springers and swells
Asparagus........	Soft and cloudy. Butyric acid odor	Water bath Cold pack	Many organisms present	Use higher temperature in processing and rapid cooling
Chocolate extract..	Sour...............	....	Yeasts	

A study of flat sours commenced by Mrs. Wyant was completed and presented as a Technical Bulletin.

Fifteen autogenous bacterins have been made for the treatment of boils and chronic infections. Six complete blood counts have also been made.

Treatment of intestinal disorders with *B. acidophilus* milk has been continued with favorable results.

[ROBERT L. TWEED.]

As indicated above, Mr. Ruehle has taken over the study of intestinal bacteriology with special reference to *B. acidophilus*. Much needs to be done, not only with this bacillus but with related species or even unrelated species significant in determining the health of man in so far as it is affected by microbial processes in the alimentary tube. Both in the commercial field and in the realm of pure research much might be done to advantage. Mr. Ruehle will have very limited opportunities because of pressure of teaching and other experimental projects, progress on which is in the nature of things very slow. Furthermore the greatest good will fail to result from research in dairy bacteriology until the applications can be made of pure bacteriological studies in dairy operations themselves. This we can accomplish only by co-operation with the Section of Dairy Husbandry which has been repeatedly recommended in previous reports.

In this connection a quotation from the presidential address of L. A. Rogers, read before the Society of American Bacteriologists in Detroit, December, 1922, is pertinent and its length pardonable.

"Although the results of research are of no immediate value unless an application can be shown, few laboratories outside of the industrial institutions have any organization for the specific purpose of applying new facts and theories to practice. It does not necessarily follow that results are lost because no special provision is made for their utilization, but it is no doubt true that many valuable results are overlooked and forgotten, because the investigation could not be carried to its logical conclusion.

If Mendel, instead of being an example of the highly individualistic type of investigator, had been a part of a modern research organization, the basic law which he discovered would not have been buried for years, but would have been put into practice at once to the great advancement of plant and animal breeding. Some investigators do not continue their investigations when they reach the applied stage because their tastes lead them to new paths in unexplored fields. In other cases the necessary equipment may not be available, or the branch of human activity to which the results may apply not at hand. The equipment needed may be a factory, a farm, a water system, or a hospital. The expense and in some investigations the danger to human life may be so great that it becomes advisable to follow the laboratory study with larger but still limited controlled experiments.

This is generally recognized in industrial laboratories where provision is usually made for carrying on investigation through the laboratory, through a miniature factory test and finally through a full scale factory operation.

In bacteriological work the same course is frequently followed, although the analogy may not be evident at first glance. The soil bacteriologist has his pots and experimental plots, the pathologist has his animals and hospital wards.

The efficiency of many other lines of investigation would be greatly increased if definite provisions could be made for carrying investigations to real completion without unnecessary delay. While in some cases it is real economy to encourage an investigator to turn to new problems of a basic nature, leaving the application of his results to others, as a rule the man who develops new principles is the one best fitted by interest and knowledge of the subject to apply them.

Many processes which work well in the laboratory develop defects when tried on a large scale. Many new methods of real value have never gotten beyond this stage, because there was no one with sufficient interest or technical knowledge to adapt the process to the new conditions. Thus there is a great economic loss which can be overcome by proper organization.

And, finally, to complete the work it is necessary to carry the results to that part of the public which is directly concerned. Is the task completed when a technical paper is published in a scientific journal? If its value lies in its use in investigational work it is usually sufficient to make it available to other scientists but if it is something which affects established practices it is only a beginning. The inertia of public opinion cannot be overcome so easily. Even the medical profession, accustomed as it is to rapid advance, cannot always be reached by the printed word alone. New developments in agricultural science permeate very slowly through the journals, the text books, and the teachers to the farms.

Report of Research Associate G. L. A. Ruehle.

As in previous years, the work of a popular nature consisted of answering letters relative to dairy and creamery hygiene. Several minor problems have also been studied during the year, but none of them yielded results of interest but two. One of these was no nearly related to my major problem that the results will be reported at some future date, and the other is being continued since more material for studying is still available. The latter is concerned with a study of the cause of liquefaction of a gelatin imbedding medium which contains considerable arsenic and in which considerable heat is used in the process of manufacture. The medium with its contained pathological specimens remains solid for several years, when it spontaneously starts to liquefy, usually in the deeper portions. When once the liquefaction starts (as a small bubble) it progresses rapidly until the whole mass of medium is liquefied. At the present writing several bacterial species have been isolated some of which can grow in the presence of 0.5 per cent arsenic trioxide, but none of these organisms were present in considerable numbers. The problem may be related to one of those being studied as a major problem and discussed below.

The research work on Adams 1 b has been carried on as outlined in my report of last year. About 200 cultures isolated from off-flavored butters have been studied for their ability to produce off-flavors in sterile milk. Some very interesting data have been secured which will be published as soon as the identifications and descriptions of the cultures can be completed. This will probably be done within the next few months.

The work on the ability of spores and dead bacterial cells to release enzymes significant in the spoilage of butter, is being continued with interesting results. A paper entitled, "The enzymic content of bacterial spores" was read at the Detroit Meeting of the Society of American Bacteriologists December 29, 1922. This paper was then submitted to the Journal of Bacteriology.

[G. L. A. RUEHLE.]

Last year the work of preparing and dispensing pure cultures of the nitrogen-fixing bacteria was in the hands of an assistant who resigned at the close of the year. This work is not simple routine but of such a nature that great skill and close attention are demanded with every operation. Damage of a negative character may result from carelessness in any step in the process. It seemed advisable to put this work back into the hands of Dr. Snyder where we would be assured it would not be neglected. The only disadvantage in this plan is that it interferes with the research work on the decomposition of peat. However, Dr. Snyder has been able to keep his project in operation. His report follows:

Report of Research Associate R. M. Snyder.

During the past year the studies on the bacterial decomposition of peat have been continued. The peat cylinders have been cropped as in previous years, and the crop threshed in order to determine the amount of seed, leaf, and stem material. Samples of the peat and drainage waters have been collected from each cylinder for further bacteriological and chemical study. The buckwheat crop obtained during the year 1920 has been rethreshed in order to obtain more information regarding the distribution of plant food between stem and leaf material. Studies have been carried on in the greenhouse on the inoculation of peat with pure cultures of cellulose decomposing organisms, and it is planned to continue this work in the future.

The course in Soil Bacteriology was taught during the Fall Term, and repeated during the Winter Term. The course in Agricultural Bacteriology for the short course students was also given during the winter.

Exhibit and demonstration material illustrating some of the more important phases of Soil Bacteriology was prepared for the State Fair and several county fairs. Plates and cultures illustrating various groups of soil organisms have been prepared and sent to a number of teachers of biology and agriculture in the secondary schools of the state.

The distribution of legume cultures to Michigan Farmers at cost has been continued as in previous seasons. Certain features concerned with the production of these cultures in the laboratory have been improved and simplified, making possible a saving of time for all concerned, and consequent reduction in cost of production. For instance, a technique for inoculating the cultures has been worked out which permits a single operator to inoculate between one and two thousand cultures per hour. We are greatly indebted to the county agents and farm bureaus for their aid and co-operation in this work. We have reason to believe that the legume cultures are of educational as well as economic value, in that through them, the farmers' attention is called more directly to some of the factors which are concerned in soil fertility. The distribution of legume cultures during the past year, tabulated according to month and crop, was as follows:

Distribution of Legume Cultures, 1922-1923.

	Alf.	S. C.	R. C.	Alsk.	S. B.	F. B.	G. B.	F. P.	C. P.	G. P.	V.	Total
July	1,185	148	40	4	198	2	....	5	18	....	58	1,658
August	2,017	148	91	14	1	....	....	....	....	....	256	2,527
September	797	112	58	58	3	....	....	....	....	....	348	1,324
February	11	9	1	....	....	....	....	....	....	....	....	21
March	577	261	230	13	....	....	....	9	....	2	....	1,092
April	5,158	1,281	893	61	....	1	3	99	....	9	89	7,594
May	3,348	712	179	19	1,636	110	7	94	224	10	20	6,359
June	1,830	121	69	5	1,286	175	1	....	162	3	5	3,757
Total	14,923	2,792	1,561	122	3,124	388	11	207	404	24	776	24,332

Alf.=alfalfa. S. C.=sweet clover. R. C.=red clover. Alsk.=alsike. S. B.=soy bean. F. B.=field bean. G. P.=garden pea. F. P.=field pea. C. P.=cow pea. G. P.=garden pea. V.=vetch.

[R. M. SNYDER.]

Mr. Cooledge is making forward strides in his studies on market milk. He has a new and refreshing point of view. His report indicates fully what he has undertaken and what he has accomplished.

Report of Research Associate Cooledge.

During the past year I have continued work upon project Adams 3a, which has the following for its object:

(a) A study of methods in use at the present time for determining the bacteriological condition of dairy products.

(b) An attempt to develop new methods where the old are found inadequate.

(c) A study of bacteriological problems relating to market milk by means of tests developed under (a).

Two papers covering work upon this project have been completed during the year and submitted to the Director for publication in bulletin form. These are: "The Colorimetric Hydrogen-ion Determination as a Means of Locating Faulty Methods at City Milk Plants," and "Paying for Milk on a Quality Basis as a Means of Improving the Supply." This latter paper was written in co-operation with Professor O. T. Goodwin, recently of the Dairy Husbandry Section.

Work which is under way in co-operation with Professor J. E. Burnett of The Dairy Husbandry Section is progressing satisfactorily and the first report will soon be ready for publication. This has to do with the relation of discarding the fore milk to low bacterial counts in the production of high grade market milk.

During the year, Mr. Howard Estes, City Milk Inspector, Flint, Michigan, submitted a report entitled "The Practicability of the pH test as a means of City Milk Control. This fulfilled one of the requirements for the degree M. Agr. which was awarded to Mr. Estes.

The following brief report is submitted:

A Study of Methods for Bacterial Analyses of Market Milk.

Bacterial counts of milk made upon different kinds of media vary considerably in number present per cubic centimenter. This is due, largely, to the composition of the media used. As one kind of medium is most suitable for the growth of certain types of bacteria it will give higher counts than other media when that particular type of organism predominates. If another type or organism predominates in the milk another medium may be expected to give the highest counts.

It occasionally happens that a sample of milk with a count of 100,000 bacteria per cubic centimeter upon one medium will have a count of only half that number upon another medium. With other samples of milk the reverse may happen. Usually, however, certain media tend to give the highest counts, while other media tend to give the lowest counts.

The usual reason for making bacteriological counts upon milk is to get an idea of how carefully the milk has been handled up to the time that the sample was taken. If the bacteriological count is low we assume that the milk has been handled in such a careful way that good keeping quality and reasonable safety are likely. If the count is very high we suspect that the milk has been so carelessly handled that good keeping quality cannot be expected and safety from disease producing organisms is in doubt.

As a member of the committee upon methods of bacterial analyses of milk and milk products appointed by the International Association of Dairy and Milk Inspectors, I undertook in 1921 to show the value of plate counts obtained upon four kinds of agar commonly used in milk work and to show the relation of the counts to the pH score. (1)

Early results of this work have been included in the committee reports (2) but my work has been continued and extended.

The methods used in this work are the 1921 Standard Methods for Bacteriological Examination of Milk, published by the American Public Health Association. Bacto Agar used in Group No. I and II is out of Lot No. 10445 which was furnished by the Digestive Ferments Company to members of the committee. Other Bacto Agar was out of regular stock. Milk-powder agar was the milk-powder Agar A described by Ayers and Mudge. (3.)

Media were adjusted to pH 6.5-6.8 where necessary. It was not necessary to adjust the reaction of Bacto Agar and Agar A.

Group No. I includes 36 samples of milk, 18 of which were taken upon a warm day and tested at once. The other 18 samples were taken from the same patrons' cans a few days later, but upon a very cool day.

Group No. II includes 48 samples of milk, 24 of which were plated upon four kinds of media and pH score determined. The samples were then incubated at room temperature for two hours and retested.

Group No. III includes samples of milk plated upon different media and incubated at 37°C. for one hour and retested.

I assume that the samples of milk in Groups II and III when plated the second time should be in poorer condition bacteriologically than when they were tested the first time. If this is true the method which shows the samples in poorer condition most consistently when tested the second time would be the best method.

Comparing the tests and retests on all of the samples of milk in Groups II and III using both the pH method and counts in various media, the sensitiveness of the methods appears as follows:

pH score	91.0%	efficient
Bacto Agar	66.6%	efficient
Meat infusion agar	66.6%	efficient
Milk powder agar A	63.3%	efficient
Beef extract agar	60.6%	efficient

Greater sensitiveness of methods would be expected if the samples have a high initial bacterial count. Methods which show poorer condition upon retest of samples with low initial counts should be the most valuable.

If only those samples of milk having a retest average count of under 25,000 bacteria per cubic centimeter are considered the efficiency of the various methods and media is as follows:

pH score	84.6%	efficient
Bacto agar	61.5%	efficient
Infusion agar	30.0%	efficient
Agar A.	30.0%	efficient
Extract agar	23.0%	efficient

Considering only those samples having a retest average count between twenty-five thousand and 100,000 the results are as follows:

pH score	85.7%	efficient
Infusion agar	85.7%	efficient
Agar A.	85.7%	efficient
Extract agar	71.4%	efficient
Bacto agar	28.5%	efficient

The samples of milk having retest counts between 100,000 and 1,000,000 bacteria per cubic centimeter give the following results:

pH score	100%	efficient
Infusion agar	100%	efficient
Bacto agar	80%	efficient
Extract agar	80%	efficient
Milk powder agar	60%	efficient

Samples of milk with retest counts of over 1,000,000 give results as follows:

pH score	100%	efficient
Bacto agar	100%	efficient
Extract agar	100%	efficient
Agar A	100%	efficient
Infusion agar	87.5%	efficient

The pH score of the samples of milk after incubation was at times the same as before but it never indicated that the milk was in better condition after the samples had been subjected to the short incubation period and retested. In three instances the pH score indicates that the milk was in no worse condition after incubation than it was before. These were samples of milk which were unusually good by this method when tested the first time.

In certain instances the samples of milk tested with the different kinds of media before and after incubation gave results which indicated that they were as good after the incubation as before. The samples may be classified as shown in Table No. 1.

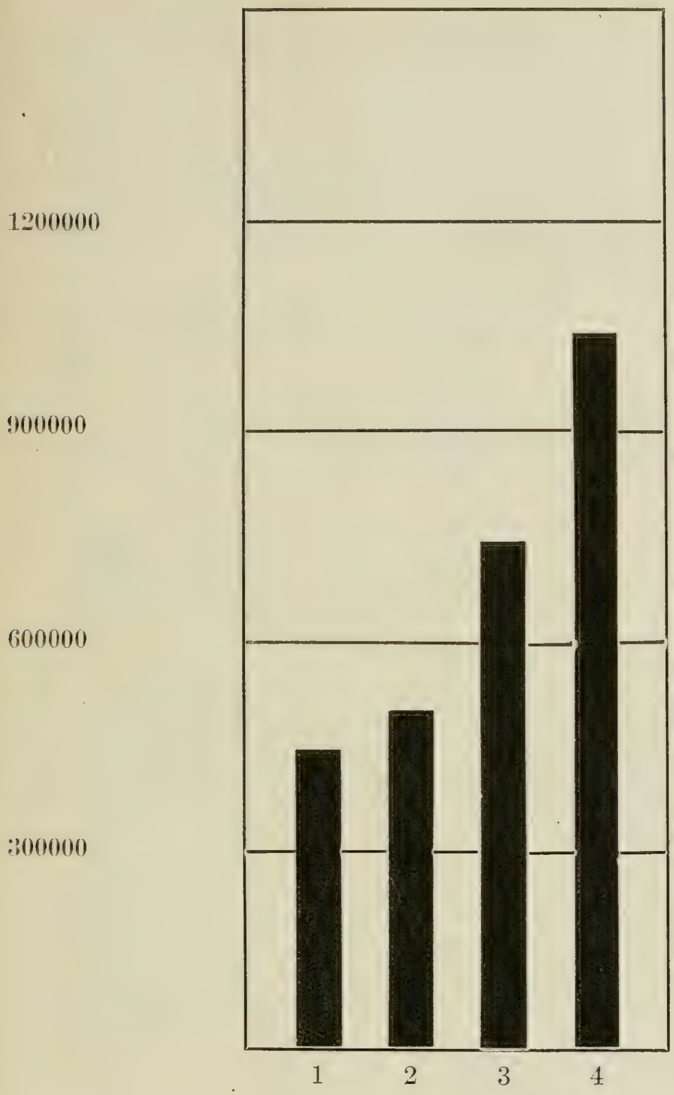
TABLE I.

Condition of milk samples upon retest after short incubation period.

How Tested	Poorer	No Change	Better
Meat extract agar	20	1	12
Milk powder agar A	20	2	11
Bacto agar	21	1	11
Meat infusion agar	22	2	9
pH score	29	3	0

It seems that after the treatment which the above samples received, efficient methods should show the samples in worse condition upon retest. A few of the samples which were in very good condition at the start might show no change upon retest, but certainly a reliable method should not indicate that a third of the samples were in improved condition.

Many investigations have been made to determine the most suitable media for milk work. It has usually been concluded in these studies that the method giving the highest counts is most efficient. It is argued that the medium giving the highest counts comes closest to giving counts which represent all of the bacteria present in the milk. There is a failure to agree upon the medium giving the highest counts. The reasons for this failure are considered below.



Effect of medium on total bacterial count. Comparison of 102 bacterial counts obtained with

1. Meat infusion agar.
2. Meat extract agar.
3. Milk powder agar A.
4. Bacto agar.

A tabulation of the samples of milk in Groups I, II, and III with average bacterial counts below 10,000 per cubic centimeter when plated upon four kinds of media shows that Bacto agar gives the highest counts and that milk powder agar A is next, with meat extract agar the lowest. When samples with 10,000 to 25,000 bacteria were studied the counts upon milk powder agar A are the highest with meat extract agar next and meat infusion agar giving the lowest counts.

If a preponderance of samples with low counts is present one investigator might be expected to find one medium giving the highest counts while another investigator studying a poorer grade of milk would find that another medium would give the highest counts.

The 102 samples of milk in Groups I, II, and III gave average counts upon the four kinds of agar as shown in Graph No. I.

When these samples were divided into groups depending upon the average count upon the four kinds of agar the medium giving the highest counts for the different groups is indicated in Table II.

TABLE II

Number of bacteria per cc. Average with 4 kinds of agar	Highest average With	Next highest With	Next lowest With	Lowest Average With
Under 10,000	Bacto agar	Agar A	Infusion agar	Extract agar
10,000— 25,000	Agar A	Extract agar	Bacto agar	Infusion agar
25,000— 50,000	Bacto agar	Agar A	Infusion agar	Extract agar
50,000— 100,000	Bacto agar	Agar A	Infusion agar	Extract agar
100,000— 200,000	Bacto agar	Agar A	Infusion agar	Extract agar
200,000—1,000,000	Agar A	Infusion agar	Bacto agar	Extract agar
Over 1,000,000	Bacto agar	Agar A	Extract agar	Infusion agar

The average bacterial count of samples tabulated in Groups No. I, II and III when arranged according to their pH scores indicates that while the pH score does not check with the bacterial count in many cases, it does check in a general way. Samples scoring 75, 70, 65, 60, and 55 because of the small numbers of samples in the various groups do not check when taken separately but do check when arranged together as shown in Table No. III.

The samples of milk scoring 50, 45, and 40 show a decrease in bacterial count. This is probably due to the fact that some of the inert types find the increased activity of the acid bacteria unfavorable.

This table does not include the nine samples of milk in Group III which were incubated at 37° F. or the two samples of pasteurized milk in Group I.

TABLE NO. III

Showing the relation of average bacteriological counts and average of pH scores.

Number of Sample	With a pH score of	Average bacterial count on four kinds of media
7	100	11,300
10	95	34,200
10	90	44,600
4	85	63,500
10	80	92,800
8	75, 70	150,000
13	65, 60, 55	562,000
14	50	5,086,000
13	45	4,178,000
2	40	2,714,000

SUMMARY.

When plating methods are used, no one medium should be expected to give results which indicate correctly the condition of all grades of milk.

The pH score proved more efficient as a means of detecting slight changes in the history of milk than did the plating methods tried.

The methods as a whole were efficient in detecting slight changes in the history of the samples as follows:

In samples with bacterial counts under 25,000—45.8% efficient.

In samples with bacterial counts between 25,000-100,000—71.4% efficient.

In samples with bacterial counts between 100,000-1,000,000—85.0% efficient.

In samples with bacterial counts over 1,000,000—97.0% efficient.

It seems that the medium giving highest average counts depends upon the predominant groups present in the sample studied. This may account for divergent results obtained by various workers.

REFERENCES.

1. Cooledge, L. H. and Wyant, R. W.—The Keeping Quality of Milk as Judged by the Colorimetric Hydrogen-ion Determination. Journal of Dairy Science, Vol. III, No. 2, March, 1920.
   Cooledge, L. H.—The Colorimetric Hydrogen-ion Determination as a Means of Studying Biological Changes in Dairy Products. Technical Bulletin No. 52, Michigan Agricultural College Experiment Station, November, 1921.
   Cooledge, L. H. and Goodwin, O. T.—An Experiment in Improving the Milk Supply of a City Milk Plant. Special Bulletin No. 112, Michigan Agricultural College Experiment Station, November, 1921.
2. Bolling, Geo. E.—Report of Committee on Methods of Bacterial Analyses of Milk and Milk Products. Tenth Annual Report and Eleventh Annual Report, International Association of Dairy and Milk Inspectors, 1921, 1922.
3. Ayers, S. Henry and Mudge, C. S.—Milk-Powder Agar for the Determination of Bacteria in Milk. Journal of Bacteriology, 5, No. 6, November, 1920.

[L. H. COOLEDGE.]

In connection with the work of Research Associate Huddleson, I wish to make a recommendation that has a far-reaching significance. Immediate steps should be taken to provide for all experimental work on animal diseases in a manner that meets the needs of the projects and at the same time conserves the interests of the sections of Dairy, Animal and Poultry Husbandry. It is not alone the work with infectious abortion but also that on poultry diseases and parasitic infestations that demands suitable housing. Now that the direction of this work has been centralized it seems opportune to make adequate provision for all the work.

At least forty acres sufficiently remote from the animal husbandry operations should be set aside for experimentation with animal diseases. As rapidly as the finances of the Station permit, buildings should be constructed and equipped to make the conduct of the research possible. The development of such a program should proceed consecutively and as the obvious needs warrant. There is no demand for a lavish expenditure with a view to the early completion of an ideal establishment.

Mr. Huddleson has been handicapped by lack of assistance and funds. He has made progress, however, as his report demonstrates.

Report of Research Associate I. F. Huddleson.

During the past year my entire time has been devoted to the project under Adams 3b, the study of bovine infectious abortion.

The following problems are being investigated at the present time many of which may project into the future.

1. Educational.
2. Diagnosis.
    - (a) Clinical.
    - (b) Serological tests.
    - (c) Allergic tests.
3. Carriers (Temporary and Permanent).
    - (a) Conditions involved in establishing carriers.
    - (b) Determination of carrier state.
    - (c) Channels through which the organism is excreted from the body.
    - (d) Habitat of organism in body.
    - (e) Destruction of carrier state.
4. Channels of infection.
5. Control.
    - (a) Sanitation and isolation.
    - (b) Immunization.
6. Cultural Studies.
7. Swine abortion.

1. *Educational.*

There is now available sufficient information concerning infectious abortion which, properly and intelligently applied, will control the spread of the disease in the infected herd and prevent its entrance into the non-infected herd.

In order to make progress in the control of infectious abortion it is necessary that certain available agencies make known to the breeder and the veterinarian the truth about the disease and the proper procedures to apply. In other words an educational campaign should be undertaken through all available sources.

2. *Diagnosis.*

The clinical studies are confined largely to observations in the experimental herd, in the field and to reports.

Although the serological tests (agglutination and complement fixation) have proved to be a reliable means for diagnosing infectious abortion in cattle and swine, there are certain phases of the technic of the test which need improving.

From these studies during the past year has evolved a paper. "The anti-complementary property of fresh bovine serum," which has been submitted to and accepted for publication in the Journal of Infectious Diseases.

Additional studies are reported here as follows:

A Serological Study of Several Strains of *Bact. abortus* (Bang).

When a certain microbe is found to be the etiological factor in a disease process, it is necessary that a detailed study be made of a number of strains of the microbe in question in order to determine if there exist different antigenic groups or sub-groups, and their possible relation to each other. The detection of antigenic difference in different strains of an organism serves a two-fold purpose: namely, further to aid in the diagnosis of the disease and the selection of strains for immunological purposes.

In grouping *Bact. melitensis* Fusier and Meyer (1) included several strains of *Bact. abortus* in the study. Their data show that *Bact. abortus* falls into one group, namely Group I of the melitensis classification.

This paper represents an attempt to detect possible serological differences of several strains of *Bact. abortus* and to place them in groups or sub-groups accordingly.

Method of Study.

A number of cultures of *Bact. abortus* which were collected from different parts of this country and Europe should serve as a fair representative of all strains now in existence. From these strains antigens were prepared for the agglutination test and employed against blood sera from aborting animals located in different parts of this country. By proceeding with the study in this manner instead of employing the usual scheme for determining serological differences in strains of an organism, it seems reasonable to believe that the particular group of organism infecting animals in different parts of the country might also be found.

The histories of the various strains of *Bact. abortus* used in this study appear in Table 1. They are practically the same strains as were used in the pathogenic studies (2). The groups of *Bact. melitensis* were included for the purpose of determining their serological relationship to infectious abortion.

The source and origin of the various samples of blood sera are as follows:

Number 1. Collected from three-year-old cow in Experiment Station herd. No history of abortion infection.

Number 2. Collected by Professor D. H. Jones, Ontario Agricultural College, Guelph, Ontario; four-year-old cow, aborted first and second calves from natural infection.

Number 3. Collected by Dr. Beach, University of California, abortion history not given.

Numbers 4, 5, 6, and 7. Collected by Dr. Fitch, University of Minnesota. Abortion history not given.

Number 8. Collected by Dr. L. L. Lewis, Oklahoma A. and M. College, from a cow which aborted a six months fetus; natural infection.

Number 9. Collected by Dr. Hallman near Traverse City, Michigan from a cow two weeks after abortion; natural infection.

Number 10. Same source as number 9; collected one week after abortion.

Number 11. Collected from four-year-old cow in Experiment Station herd one month after abortion; natural infection.

Number 12. Collected by Dr. Connaway, University of Missouri, from eight-year-old cow; aborted fifth calf; natural infection.

Number 13. Same source as number 12; from four-year-old cow; aborted second calf; natural infection.

Number 14. Same source as number 12; from eleven-year-old cow; aborted first, second and fifth calves; natural infection.

Number 15. Same source; from three-year-old cow; aborted first calf; natural infection.

PATHOGENICITY OF BACTERIUM ABORTUS (BANG).

TABLE I

Showing History of Strains of Bact. Abortus Employed in the Comparative Studies

Strain	Date if Isolation	Origin
1	Unknown	Received from Bureau of Animal Industry prior to 1915
2	1915	Aborted fetus (from Herd A).
3	1915	Aborted fetus (from Herd A)
6	1915	Udder of Cow 995 (Abortion Experimental Herd)
7	Unknown	In laboratory prior to 1916
16	June, 1917	Aborted fetus, Owosso, Michigan
21	May, 1919	Placenta of cow following abortion, Ubly, Michigan
21	December, 1919	Aborted fetus (Herd D)
22	September, 1919	Aborted fetus (from Herd A)
805	May, 1919	Placenta of cow 805 following abortion (Abortion Experimental Herd)
C	March, 1917	Aborted fetus (from Herd A)
W	Unknown	Received from Wisconsin University, 1915.
J	1916	Aborted fetus (from Herd B)
E	Prior to 1916	Unknown
Germany	Unknown	Obtained in Germany in May, 1919
England	Unknown	Royal Veterinary College, April, 1919
60	February, 1920	Udder of cow (from Herd A)
100	June, 1920	Udder of Cow No. 100 (Abort. Expt. Herd)
200	January, 1920	Udder of cow No. 200 (Abortion Expt. Herd)
L	December, 1920	Aborted fetus (from Herd A)
1 Swine	March, 1920	Aborted fetus of sow near Lansing, Michigan
2,010 Swine	Received 9-3-20	Dr. Graham, Illinois University
1 Melitensis	Received 1-19-20	American Museum of Natural History
27 Melitensis	Received 5-15-21	Doctor Meyer, University of California
22 Melitensis	Received 5-15-21	Doctor Meyer, University of California

Agglutination Test. The several antigens were prepared by growing each strain of *Bact. abortus* on liver agar (pH 6.6) in Kolle flasks for forty-eight hours, removing the growths with physiological salt solution plus 0.5 per cent phenol, filtering through sterile gauze to remove clumps, mechanically shaking for four hours and finally standardizing to a turbidity of three by the McFarland nephelometer. In the tests, two cubic centimeters of the antigen were placed in each of four small test tubes and serum added in the following quantities: 0.05, 0.025, 0.01

and 0.005 cc. The tubes were incubated at 37° C. for eighteen hours and the results recorded as follows: + = complete clumping, P = incomplete clumping and o = no clumping. The degrees of incomplete clumping are not recorded here as it is doubtful if any two workers would read the degree of clumping alike.

Results of Study.

Table II illustrates the degree of agglutination of twenty-one strains of *Bact. abortus* by fifteen different bovine sera, fourteen of which were from animals which had aborted from a natural infection, and one, number 1, had no history of ever being infected. Incidentally, the concentration of agglutinins in each serum examined varied widely. Such variations are of considerable aid in separating out slightly different groups of the organism. A "pro-agglutinating" serum (No. 10) was encountered at this time and introduced into the group. There was little or no difference in the degree of pro-agglutination for the several antigens employed. In studying this phenomenon, it was found that if the density of the antigen was lowered the dilution of serum in which pro-agglutination occurred was increased, but if the density was increased to a certain degree the negative has disappeared, and complete agglutination occurred in all tubes.

It is evident from the tabulated results that there is no difference in the agglutinability of the several cultures of *Bact. abortus*: occasionally a serum would fail to agglutinate one or two strains to the same degree, but as these results would often be reversed in other sera, it was decided that the variations were due to the failure of placing the exact amount of serum in similar tubes. The failure of serum number 11 to agglutinate a single antigen is of considerable importance as it gave a complete fixation of complement in 0.005 c.c. The sample was taken from a cow shortly after abortion.

The group to which *Bact. melitensis* I. belongs is not known. It may be noted that it is only appreciably agglutinated by sera from animals infected with *Bact. abortus*. *Bact. melitensis* No. 7 belongs to Group II, and 22 to Group IV as found by Fusier and Meyer (1). *Bact. melitensis* 27 appears to be agglutinated by all sera to the same degree as the strains of *Bact. abortus,* while 22 was not clumped by a single serum.

The agglutinability and the pathogenicity of *Bact. abortus* appear to be separate and distinct properties, neither of which is indicated by the other. Old, non-pathogenic strains are as agglutinable as newly isolated strains.

TABLE II

Comparative Agglutination Studies on Twenty-four Strains of Bact. Abortus with Sera Nos. 1, 2 and 3

Strain	Serum No. 1, Dil.				Serum No. 2, Dil.				Serum No. 3, Dil.			
	.05	.025	.01	.005	05	025	.01	.005	.05	.025	.01	.005
1	0	0	0	0	+	+	0	0	+	+	+	+
2	0	0	0	0	+	+	0	0	+	+	+	+
3	0	0	0	0	+	+	+	0	+	+	+	+
6	0	0	0	0	+	+	+	0	+	+	+	+
7	0	0	0	0	+	+	+	0	+	+	+	+
16	0	0	0	0	+	+	+	0	+	+	+	+
20	0	0	0	0	+	+	P	0	+	+	+	+
21	0	0	0	0	+	+	+	0	+	+	+	+
22	0	0	0	0	+	+	+	0	+	+	+	+
60	0	0	0	0	+	+	+	0	+	+	+	+
200	0	0	0	0	+	+	+	0	+	+	+	+
805	0	0	0	0	+	+	+	0	+	+	+	+
2010 Swine	0	0	0	0	+	+	+	0	+	+	+	+
1 Swine	0	0	0	0	+	+	+	0	+	+	+	+
J	0	0	0	0	+	+	+	0	+	+	+	+
W	0	0	0	0	+	+	+	0	+	+	+	+
E	0	0	0	0	+	+	+	0	+	+	+	+
L	0	0	0	0	+	+	+	0	+	+	+	+
C	0	0	0	0	+	+	+	0	+	+	+	+
England	0	0	0	0	+	+	P	0	+	+	+	+
Germany	0	0	0	0	+	+	+	0	+	+	+	+
Mel. 1	0	0	0	0	0	P	P	0	+	P	P	0
Mel. 27	0	0	0	0	+	+	P	0	+	+	+	+
Mel. 22	0	0	0	0	0	0	0	0	0	0	0	0

Comparative Agglutination Studies on Twenty-four Strains of Bact. Abortus with Sera Nos. 4, 5, and 6.

Strain	Serum No. 4, Dil.				Serum No. 5, Dil.				Serum No. 6, Dil.			
	.05	025	01	.005	.05	025	.01	005	.05	025	.01	005
1	+	+	+	P	+	+	+	P	+	+	+	P
2	+	+	+	P	+	+	+	+	+	+	+	+
3	+	+	+	0	+	+	+	P	+	+	+	P
6	+	+	+	P	+	+	+	P	+	+	+	+
7	+	+	+	P	+	+	+	+	+	+	+	0
16	+	+	+	P	+	+	+	+	+	+	+	P
20	+	+	+	P	+	+	+	P	+	+	+	0
21	+	+	+	0	+	+	+	P	+	+	+	+
22	+	+	+	+	+	+	+	P	+	+	+	+
60	+	+	+	+	+	+	+	+	+	+	+	0
200	+	+	+	+	+	+	+	P	+	+	+	P
805	+	+	+	P	+	+	+	P	+	+	+	0
2010 Swine	+	+	+	+	+	+	+	P	+	+	+	+
1 Swine	+	+	+	+	+	+	+	+	+	+	+	+
J	+	+	+	0	+	+	+	+	+	+	+	+
W	+	+	+	P	+	+	+	0	+	+	+	P
E	+	+	+	+	+	+	+	P	+	+	+	+
L	+	+	+	+	+	+	+	+	+	+	+	0
C	+	+	+	+	+	+	+	+	+	+	+	+
England	+	+	+	P	+	+	+	P	+	+	+	0
Germany	+	+	+		+	+	+	P	+	+	+	P
Mel. 1	P	0	0	0	P	0	0	0	P	0	0	0
Mel. 27	+	+	+	P	+	+	+	P	+	+	+	0
Mel. 22	0	0	0	0	0	0	0	0	0	0	0	0

Comparative Aggultination Studies on Twenty-four Strains of Bact. Abortus with Sera Nos. 7, 8, and 9.

Strain	Serum No. 7, Dil.				Serum No. 8, Dil.				Serum No. 9, Dil.			
	.05	025	.01	005	.05	.025	.01	.005	.05	.025	.01	.005
1	+	+	+	P	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+	+	+	+	+
3	+	+	+	0	+	+	+	+	+	+	+	0
6	+	+	+	+	+	+	+	+	+	+	+	P
7	+	+	+	P	+	+	+	+	+	+	+	P
16	+	+	+	P	+	+	+	+	+	+	+	P
20	+	+	+	P	+	+	+	+	+	+	+	P
21	+	+	+	P	+	+	+	+	+	+	+	P
22	+	+	+	0	+	+	+	+	+	+	+	P
60	+	+	+	+	+	+	+	+	+	+	+	P
200	+	+	+	+	+	+	+	+	+	+	+	+
805	+	+	+	P	+	+	+	+	+	+	+	P
2010 Swine	+	+	+	0	+	+	+	+	+	+	+	+
1 Swine	+	+	+	+	+	+	+	+	+	+	+	+
J	+	+	+	+	+	+	+	+	+	+	+	P
W	+	+	+	P	+	+	+	+	+	+	+	P
E	+	+	+	P	+	+	+	+	+	+	+	P
L	+	+	+	+	+	+	+	+	+	+	+	+
C	+	+	+	+	+	+	+	+	+	+	+	P
England	+	+	+	0	+	+	+	+	+	+	+	P
Germany	+	+	+	P	+	+	+	+	+	+	+	P
Mel. 1	P	0	0	0	P	P	0	0	P	P	0	0
Mel. 27	+	+	+	0	+	+	+	+	+	+	+	+
Mel. 22	0	0	0	0	0	0	0	0	0	0	0	0

Comparative Aggultination Studies on Twenty-four Strains of Bact. Abortus with Sera Nos. 10, 11, and 12.

Strain	Serum No. 10, Dil.				Serum No. 11, Dil.				Serum No. 12, Dil.			
	.05	.025	01	005	05	.025	.01	.005	.05	.025	01	.005
1	0	0	0	P	0	0	0	0	+	+	+	+
2	0	0	+	+	0	0	0	0	+	+	+	+
3	0	0	0	+	0	0	0	0	+	+	+	+
6	0	0	P	+	0	0	0	0	+	+	+	+
7	0	0	0	+	0	0	0	0	+	+	+	+
16	0	P	+	+	0	0	0	0	+	+	+	+
20	0	+	+	P	0	0	0	0	+	+	+	+
21	0	P	P	+	0	0	0	0	+	+	+	+
22	0	0	0	+	0	0	0	0	+	+	+	+
60	0	+	+	+	0	0	0	0	+	+	+	+
200	0	0	+	+	0	0	0	0	+	+	+	+
805	0	P	+	+	0	0	0	0	+	+	+	+
2010 Swine	0	0	0	+	0	0	0	0	+	+	+	+
1 Swine	0	0	0	+	0	0	0	0	+	+	+	+
J	0	0	P	+	0	0	0	0	+	+	+	+
W	0	0	P	+	0	0	0	0	+	+	+	+
E	0	0	0	+	0	0	0	0	+	+	+	+
L	0	0	+	+	0	0	0	0	+	+	+	+
C	0	+	+	+	0	0	0	0	+	+	+	+
England	0	0	P	P	0	0	0	0	+	+	+	+
Germany	0	0	0	P	0	0	0	0	+	+	+	+
Mel. 1	0	0	0	0	0	0	0	0	P	P	P	0
Mel. 27	0	+	+	+	0	0	0	0	+	+	+	+
Mel. 22	0	0	0	0	0	0	0	0	0	0	0	0

Comparative Aggultination Studies on Twenty-four Strains of Bact. Abortus with Sera Nos. 13, 14, and 15.

Strain	Serum No. 13, Dil.				Serum No. 14, Dil.				Serum No. 14, Dil.			
	05	025	01	.005	.05	025	01	.005	05	.025	.01	.005
1	P	0	0	0	+	+	+	+	+	+	0	0
2	P	0	0	0	+	+	+	+	+	P	0	0
3	P	0	0	0	+	+	+	+	+	+	0	0
6	P	0	0	0	+	+	+	+	+	P	0	0
7	P	0	0	0	+	+	+	+	+	+	0	0
16	P	0	0	0	+	+	+	+	+	P	0	0
29	P	0	0	0	+	+	+	+	+	P	0	0
21	+	P	0	0	+	+	+	+	+	+	0	0
22	P	0	0	0	+	+	+	+	+	P	0	0
60	+	P	0	0	+	+	+	+	+	+	0	0
200	P	0	0	0	+	+	+	+	+	+	0	0
805	P	0	0	0	+	+	+	+	+	+	0	0
2010 Swine	+	P	0	0	+	+	+	+	+	+	0	0
1 Swine	P	0	0	0	+	+	+	+	+	P	0	0
J.	+	+	0	0	+	+	+	+	+	+	0	0
W	P	P	0	0	+	+	+	+	+	P	0	0
E.	+	0	0	0	+	+	+	+	+	P	0	0
L.	·P	0	0	0	+	+	+	+	+	+	0	0
C.	P	0	0	0	+	+	+	+	+	P	0	0
England	P	0	0	0	+	+	+	+	+	+	0	0
Germany	P	0	0	0	+	+	+	+	+	+	0	0
Mel. 1	P	0	0	0	P	P	0	0	P	P	0	0
Mel. 27	P	P	0	0	+	+	+	+	+	+	0	0
Mel. 22	0	0	0	0	0	0	0	0	0	0	0	0

SUMMARY.

There does not appear to be any individual difference in the agglutinability of 21 strains of *Bact. abortus* procured from different parts of this country and Europe. Taking the agglutination results on fifteen sera as a criterion, there does not appear to be any difference in the type of *Bact. abortus* which invades the tissues of animals in different districts of this country.

Bibliography.

1. Fusier, M. L., and Meyer, K. F.,
Principles in serologic grouping of *B. abortus* and *B. melitensis*. Correlation between absorption and agglutination tests. Jour. Inf. Dis., Vol. 27, p. 185, 1922.
2. Huddleson, I. F.,
The comparative pathogenicity of several strains of *Bact. abortus* (Bang). Mich. Agr. Exp. Sta. Technical Bulletin 55, March, 1922.

The Influence of Different Preservatives on the Agglutinability of Bact. abortus.

It is of considerable practical importance that the sensitivity of the agglutination test for the diagnosis of infectious abortion should be fully developed. In view of the fact that the addition of foreign agents or material may affect the agglutinability of the antigen, the influence of different preservatives such as phenol, tricresol, ether, formalin and no preservative are herein considered.

The antigen was prepared in the manner previously described and suspended in physiological salt solution. To a series of suspensions were added phenol to 0.5 percent, tricresol to 0.1 per cent, formalin to 0.5 per cent and ether to 0.5 per cent. The antigens were placed in the ice-box for 24 hours before using.

The 28 sera used represent a small number of sera sent to the laboratory for diagnosis. They were used unheated owing to the fact that we have found that serum agglutinins, as shown in Table II, are partially or totally destroyed in many cases when heated at 56° C. for thirty minutes.

The agglutination tests were conducted as previously described.

Table I illustrates the effects of the different preservatives on the reaction. The slight degree of difference represented here between antigens containing phenol, formalin and ether is within the limit of experimental error and should not be considered. There is a marked influence on the agglutinability of the antigen preserved with tricresol to the extent of inhibiting clumping completely or causing zone agglutination. Formalin should not be used in the antigen in a greater concentration than given here as it will also inhibit clumping in many cases, but not in all. Comparative tests with fresh unheated and heated (56° C. for 30 minutes) antigens and those preserved with phenol, formalin or ether showed no increased sensitivity in favor of the unpreserved antigens.

The Agglutinability of Bact. Abortus Antigen Containing Different Preservatives. (Incubated at 37° C. for 18 Hours.)

Serum No.	Antigen Containing 0.5% Phenol				Antigen Containing 0.1% Cresol				Antigen Containing 0.5% Formalin				Antigen Containing 0.5% Ether			
	Serum Dil.				Serum Dil.				Serum Dil.				Serum Dil.			
	025	.01	005	.001	025	01	005	001	025	01	005	001	025	.01	005	001
805D	+	0	+	0	0	0	0	0	0	0	+	0	+	0	+	0
119	+	+	+	P	+	+	0	0	+	+	P	P	+	+	+	P
200	+	+	+	+	+	+	+	+	0	0	+	+	+	+	+	+
200B	+	+	+	+	+	+	0	0	0	+	+	+	P	+	+	+
805A	+	0	0	0	0	0	0	0	+	0	0	0	+	0	0	0
999A	+	0	0	0	0	0	0	0	+	0	0	0	+	0	0	0
997D	+	P	0	0	P	0	0	0	+	P	0	0	+	P	0	0
104	+	+	+	0	+	+	P	0	+	+	+	P	+	+	+	P
102	+	+	P	0	+	+	0	0	+	+	P	0	+	+	0	0
999D	+	+	0	0	+	0	0	0	+	+	0	0	+	+	0	0
802A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	+	+	+	0	P	0	0	0	0	0	0	0	+	P	P	0
3	+	+	+	0	0	0	0	0	0	0	+	0	+	+	+	0
4	+	+	+	0	0	0	0	0	0	0	+	0	+	+	+	0
1D	+	+	+	P	P	P	0	0	P	P	0	0	+	+	+	P
2D	+	+	+	+	+	P	0	0	+	+	+	+	+	+	+	+
3D	+	+	+	+	+	P	P	0	+	+	+	+	+	+	+	+
4D	+	+	+	+	+	+	0	0	+	+	+	+	+	+	+	+
5D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1659	+	+	+	+	+	+	P	P	+	+	+	+	+	+	+	+
1666	+	+	+	+	+	+	P	0	+	+	+	+	+	+	+	+
1667	+	+	+	+	+	+	0	0	0	0	0	0	+	+	+	+
1668	+	+	+	0	+	P	0	0	+	+	+	0	+	+	+	+
1L	+	+	+	+	+	+	0	0	+	+	+	+	+	+	+	+
7L	+	+	+	+	+	P	0	0	+	+	+	+	+	+	+	+
1B	+	+	+	+	+	0	0	0	+	+	+	0	+	+	+	0
3B	+	+	+	+	P	0	0	0	+	+	P	0	+	+	P	0
5B	+	+	+	+	+	+	0	0	+	+	+	+	+	+	+	+

The Effect of Heat on Serum Agglutinins. (Incubated at 37° C. for 18 Hours).

Serum No.	Unheated				Heated			
	Serum Dil.				Serum Dil.			
	.05	.025	.01	005	.05	.025	.01	.005
1	+	+	+	P	0	0	0	0
2	+	+	+	+	+	+	P	0
3	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	0
805D	+	0	+	0	0	0	0	0
119	+	+	+	P	0	P	P	0
58	+	P	0	0	P	P	0	0
57	P	0	0	0	0	0	0	0
28	+	+	+	+	0	0	P	P
45	0	0	0	0	0	0	0	0
35	+	+	+	0	P	P	0	0
14	+	+	+	+	+	+	+	+
49	+	+	+	+	0	0	0	0
19	+	P	P	0	0	0	0	0
26	+	+	+	+	+	+	+	+
54	+	+	+	+	+	+	+	+
18	+	0	0	0	P	0	0	0
11	+	+	+	P	+	+	+	P
1	+	+	+	+	0	0	P	P
15	+	+	+	+	0	P	P	+
16	+	+	+	+	+	P	0	0
190	0	0	0	0	0	0	0	0
20	+	+	+	P	P	+	+	0
21	P	0	0	0	P	0	0	0
180	+	+	+	+	+	+	+	+
802A	+	+	P	0	+	+	0	0
999A	+	P	0	0	+	P	0	0
997D	+	+	+	+	+	+	+	+
29	+	+	0	0	+	P	0	0
90	+	+	+	P	+	+	+	+
1L	+	+	+	P	+	+	P	0
2L	+	+	+	0	+	+	+	0
3L	+	+	0	0	+	+	+	+
4L	+	+	+	0	+	+	P	0
5L	+	+	+	0	0	0	0	0
7L	+	+	+	+	+	P	0	0
8L	+	+	+	0	+	P	0	0
1698L	+	+	+	P	+	P	P	0
1B	+	+	0	0	P	0	0	0
2B	+	+	+	+	P	0	0	0
3B	+	+	P	0	+	+	P	0
5B	+	+	+	+	+	+	P	0

Comparison of Serological Test by Different Laboratories.

For the past eight months Dr. C. P. Fitch of the University of Minnesota and myself have been exchanging blood samples from cattle for the purpose of comparing the diagnostic tests (agglutination and complement fixation) in use at the two laboratories in order to determine whether the results from his technic and our technic agree. Agreement in results by all laboratories is very essential if the tests are ever to be placed on a universal diagnostic basis.

Up to the present time we have conducted these tests on about 300 samples of serum. The tests show that there is a considerable difference in our results. By slight changes in technic we hope to bring our results into complete agreement.

3. *Carriers.*

Considerable progress has been made on this problem, but not sufficient to warrant a definite statement except on the destruction of the carrier state.

In order to destroy in a host a microparasite which appears to have therein a permanent abode, one must consider those agents which (1) increase the defensive mechanism of the host and (2) destroy the parasite directly.

Concerning the former, sufficient data have been collected to show that killed and living (non-virulent) cultures, bacterins, and vaccines, have no effect upon the carrier state. The direct action of one agent "collargol" on the organism in the body is reported below.

The Treatment of Bovine Infectious Abortion With Collargol.

Ziemann, in 1921, reported considerable success in the treatment of malta fever in humans by means of collargol. Since the organism concerned in the etiology of malta fever and in infectious abortion are in many respects similar if not identical, it was thought that this agent might prove to be of considerable value in the treatment of animals infected with *Bact. abortus.*

Two groups of dairy cows were used in this experiment. The first group consisted of 16 cows. Blood tests were made on all animals on Nov. 13, 1922, of which 5 gave positive reactions. Of these 2 had previously aborted. On November 24, 1922, the 5 reacting animals received intravenously 20 cc. of a 2 per cent aqueous solution of collargol.

One of the treated cows aborted a 5-months fetus January 1, 1923, and one untreated cow aborted a 7-months fetus February 1, 1923. On May 2, 1923, blood tests were again made on the entire herd. The five treated animals which formerly reacted were positive, including the negative reactor which aborted February 1, 1923.

The second group consisted of 21 dairy cows. Blood tests were made on all animals on January 1, 1923, of which 10 were positive. Of these reactors 5 had previously aborted. The 10 reactors received intravenously 20 cc. of a 2 per cent aqueous solution of collargol January 7, 1923. The injection was repeated March 7, and May 7, 1923. One cow showed a considerable reaction from the second injection and all appeared to be in distress from the third injection. The most pronounced symptoms were watering of the eyes and loss of appetite which lasted for several days.

Blood tests made before each injection showed no change in reaction. None of the negative reactors became positive during this time. One of the treated animals aborted February 5, 1923.

In summing up the results it is only necessary to say that collargol is of doubtful value in the treatment of infectious abortion, and that its continued use is injurious and dangerous.

4. *Channels of infection.*

Although there is fairly definite knowledge of the routes through which *Bact. abortus* enters the body of its host, there are yet many questions which have not been settled. Studies and observations on this phase of the problem will be continued.

5. *Control.*

A practical procedure for the control of infectious abortion was presented in the Michigan Agricultural College Quarterly Bulletin, Vol. 5, No. 4, p. 178, 1923.

The results of using killed and living (non-virulent) cultures of *Bact. abortus* the purpose of immunization are now being compiled. No statement of the results will be made at this time.

6. *Cultural Studies.*

This is one of the most important phases of the abortion problem. Around the organism itself are centered many problems, and new problems are continually presenting themselves.

Problems along this line which are now being studied are the effect of different atmospheric conditions on the growth, antigenic and pathogenic properties of *Bact. abortus*, pathogenic and non-pathogenic strains of *Bact. abortus*, and a *Bact. abortus* like organism. The following experiment has been completed and is here given in detail.

The Effect of a partial Atmosphere of Carbon-dioxide Gas on the Bacteriological and Pathogenic Properties of Bact. Abortus.

In a former publication it was shown that carbon-dioxide gas plays an important part in the primary cultivation of *Bact. abortus* by changing the hydrogen-ion concentration of the atmosphere in which the organism is placed.

From our studies and those of others, it appears that this particular atmospheric condition is found in the fluids surrounding the developing fetus and in the udder, both of which are favorable seats for the localization of *Bact. abortus.* A large number of examinations has shown that the hydrogen-ion concentration of fetal fluids, at different periods of gestation, ranges between 6.6 and 7, and the CO_2 tension by volume between 10 and 15 per cent. The hydrogen-ion concentration of freshly drawn milk has a range of 6.6 to 7.2 and CO_2 tension by volume between 8 and 15 per cent.

In view of the above facts one experiment was designed to determine what influence a CO_2 tension favorable for the growth of *Bact. abortus* would have on its pathogenic, agglutinating and morphological characteristics.

Two non-pathogenic strains of *Bact. abortus* (805 and 1) and two pathogenic strains (300 and 670) as determined by their ability to produce characteristic changes in the organs of guinea pigs were selected for the study. The medium used for cultivation was liver agar pH 6.6. The inoculated media were placed in an improvised Novy anaerobic jar and 10 per cent of the air replaced by CO_2 gas. The cultures were incubated at 37° C. for 24 hours and transfers made and incubated as before. This procedure was repeated daily for 50 days on the pathogenic strains and for 100 days on the non-pathogenic strains. On each 25th day throughout, guinea pigs were inoculated with 0.5 c.c. of a saline suspension of one agar slant (turbidity of suspension by McFarland nephelometer was 3) to determine change in pathogenicity. The pigs were killed at the end of eight weeks and the organs examined for lesions. Agglutination tests were made on the strains with a positive serum and transplants were made and cultured aerobically to determine if they would still grow aerobically.

The above determinations were made twice, on the 25th and the 50th days, for the pathogenic strains, and four times, on the 25th, 50th, 75th and 100th days, for the non-pathogenic strains.

The results are as follows: There was no change in the pathogenicity of the four strains, that is, the non-pathogenic remained non-pathogenic, and the pathogenic strains showed no loss or increase in lesion-producing power.

The period of cultivation has no influence on the agglutinability of the four strains.

There was no apparent change in the morphology of the organisms.

7. *Swine Abortion.*

The studies on swine abortion have been completed for the present. The final results of this problem have been submitted for publication in the Michigan Agricultural College Experiment Station Quarterly. The results indicate that swine do not certainly become infected from ingesting milk containing *Bact. abortus* or from associating with infected cows.

A paper was submitted at the annual meeting of the American Veterinary Medical Association by Ward Giltner, R. L. Tweed and I. F. Huddleson on "The role of the udder and its secretion in bovine infectious abortion," and published later in the Journal of the Am. Vet. Med. Assoc., Vol. 15, No. 2, p. 172, 1922.

There were received during the past year 455 samples of blood (bovine) for diagnosis of infectious abortion of which 136, or 29 per cent, were positive, and 319 were negative to the blood tests. The above number of blood samples does not include those taken from animals in the experimental herd or duplicate tests on herds in which immunization studies are being conducted.

Our experimental herd at the present time is comprised of 8 cows, 10 heifers, 4 calves and 2 bulls.

[I. Forest Huddleson.]

One of the most important phases of the work of this Section is with the great poultry disease problem of the State. The problem is not peculiar to Michigan, and it is not being investigated alone in this State, but we have our full share of the various diseases of poultry since the industry is extensive, and it is only proper that we do our full share in contributing to an understanding of the troubles. It seems impossible to do adequate instructional or extension work in poultry husbandry without accompanying research. We are fortunate in having in Dr. Stafseth a man, not only well trained, but one possessed of tremendous energy and an unusual vision of his field. He should have more and more assistance in both research and in field work. His report conclusively demonstrates the magnitude of the task.

Report of Research Associate H. J. Stafseth.

During the year of 1922-1923 my time has been taken up largely by routine examination of specimens sent in for diagnosis and by teaching. Last year 146 specimens were examined bacteriologically or pathologically. This year we examined 686. There were 2,779 blood samples tested by the agglutination test during the fall of 1921 and winter of 1922. The fall and winter of 1922-1923 show an increase to 5,297.

Responses have been made to sixteen calls from poultry associations and county agents to visit various sections of the state for the purpose of investigating outbreaks of poultry diseases and giving instructions relative to prevention and control. The very extensive correspondence connected with this work has demanded a great deal of time and thought. Farm papers and poultry journals have sent in numerous requests for information which has been given in the form of articles or answers to specific questions. Inquiries regarding poultry disease problems have also been received from Iowa, Ohio, Indiana, Missouri, Illinois, California, Kansas, and Ontario.

Graduate assistants, Miss Dorothy Yakeley and Mr. R. C. Thomas, have rendered valuable assistance. Miss Yakeley has spent about one-half of her time on her major problem, "A study of the microflora of the intestines of normal chickens." Mr. Thomas has not selected a problem but has spent about one-quarter of the time to the study of the pathogenic bacteriology and immunology preparing to take up a problem in this branch of bacteriology.

It is apparent that while the work that we have had to do has greatly increased, the assistance available has been less than that of the previous season during which time I had a technician devoting about three-quarters of his time to my work, besides the help which I was able to get from a senior student.

The following table shows the results of 686 autopsies:

TABLE OF AUTOPSIES

Disease	No. of Specimens Examined
Arthritis in chickens	1
Aspergillisis in chickens	2
Bacillary white diarrhea	227
Blackhead in turkeys	3
Blackhead in chickens	8
Blindness in chickens	1
Chickenpox	25
Coccidiosis in chickens	13
Colibacillosis in chickens	18
Crop bound	1
Empyema of chickens	1
Fibroma in cow	1
Fowl cholera	122
Fowl typhoid	13
Hematoma of chicken	1
Hemorrhage from comb	3
Hemorrhage from liver in chickens	4
Hemorrhage from ovary in chicken	2
Hemorrhage septicemia in cattle	3
Leukosis in chickens	7
Malnutrition in chickens	6
Mastitis in cattle	1
Multiple abscesses in rabbit	1
Pneumonia in chickens	4
Polyneuritis in chickens	1
Roup in chickens	8
Sarcomatosis of chickens	10
Tuberculosis of chickens	48
Undetermined	79
Unfit for examination	35
Visceral gout	9
Worms	25
Wires or nails penetrating gizzard in chickens	3
Total	686

Of the 5,297 blood samples examined for bacillary white diarrhea infection in chickens 1,032 were positive, 760 partial, 238 unfit for the test and the rest were negative. Delay in transit was largely responsible for rendering samples unfit.

The work started during the year of 1921-1922 on the intradermal tuberculin test in the chickens has to be discontinued due to cold weather and lack of housing facilities. Our experiments on the transmission of bacillary white diarrhea infection from male to female and vice versa were terminated partly for the same reasons and partly because a considerable number of our birds were stolen. However, the data obtained may be sufficient for a preliminary report which is being prepared for publication.

Excellent opportunities for a combined field and laboratory study of fowl cholera as it occurred during the past fall and winter was offered by the willing co-operation of the poultry department. The results of this study are summarized in the Michigan Agricultural College Quarterly Bulletin, Vol. 5, No. 4, May, 1923.

[H. J. STAFSETH.]

Professor Fabian has only a limited time to devote to investigational work, but he uses it to advantage. He is interested in the bacteriology of the apiary, of ice cream making, vinegar manufacture, flax retting, and the fermentation industries generally. A brief statement of his work follows:

Report of Research Associate F. W. Fabian.

During the past year, in addition to my regular teaching schedule, I have written up and have had accepted by the Station Council, Technical Bulletin No. 60, entitled "The Influence of Manufacturing Operations on the Bacterial Content of Ice Cream." This work was done with R. H. Cromley, a former student. Continuing further investigations along this same line, I have completed a study of the influence of homogenizing on the bacterial content of ice cream, and have started work on the influence of freezing on the bacterial content of ice cream both of which I hope to publish at an early date.

In addition to the above work, I have analyzed several samples of spoiled honey and isolated several organisms causing the spoilage. I hope to be able to do more work with spoiled honey and get sufficient data for an understanding of the causes, nature, and prevention of the trouble. I have recently taken over that part of the work of R. L. Tweed which had to do with fermentation and with the sending out of vinegar cultures in addition to the large number of samples of vinegar that this laboratory is called upon to analyze during the year.

[F. W. FABIAN.]

In our report of last year we called attention to the fact that Miss Antoinette Trevithick had been appointed to a position in the Bureau of Plant Industry of the United States Department of Agriculture. Her work has been carried on in this laboratory since September 15, 1922, under this appointment and has consisted in a continuation of studies of a preliminary character conducted by her as an advanced student in bacteriology during the previous year. The co-operative arrangement will continue during the ensuing year. Her report as submitted to the Bureau of Plant Industries follows:

Report of Antoinette Trevithick on Flax Retting.

The object of my work is to determine the micro-organisms or group of micro-organisms best suited to flax retting, and to determine methods of propagating them, and the optimum environmental factors with the aim of producing uniform and superior quality of fiber. Since starting my work September 15, 1922, I have accomplished the following results:

I have read all the available literature on pure culture and water retting in general, also on pectin. I have isolated and purified 91 cultures obtained from Japanese, Chilean, Dutch, Irish and Courtrai retted fiber and have tried these out for retting ability on small quantities of sterilized straw and river water. By this process 48 cultures have been eliminated as non-retters. Those which have been retained as retters will be tried out on larger quantities of sterilized straw and eventually on non-sterilized straw. I am running a number of cultures at the same time under the same conditions in order to be able to compare the fibers. From my work so far it appears that I have found the organisms responsible for retting. As yet I have not been able to make a very thorough study of my organisms for quality of fiber produced, but I have produced on a small scale fiber which Mr. Davis, Asst. Plant Breeder, Office of Fiber-Plant Investigations, Bureau of Plant Industry, said compares well with Courtrai fiber. I expect to be able to do more with fiber quality this summer on morphological and cultural characteristics. I have done a small amount of work with six organisms which have been quite extensively tried for retting. They were isolated from four sources and seem to be two different types of organisms. I have not carried this study far enough as yet to make any definite statements. I can say that my organisms are facultative aerobes and that I have found so far that 30° C. is the best temperature for retting although retting will take place from 20° C. to 35° C. Mr. Davis and I spent considerable time last fall trying to work up a more efficient retting test. Mr. Davis has submitted for publication the results of this work. I might also add that I have been trying to become more efficient at detecting the grade of fiber as determined by fineness, luster, softness and other properties.

[ANTOINETTE TREVITHICK.]

We are recommending that Assistant Professor W. L. Mallmann be made also Research Assistant in the Experiment Station. The needs of this Section as well as the training and ambitions of Mr. Mallmann make this a logical procedure. His report follows:

Report of W. L. Mallmann.

The number of samples of water examined this year was less than last year but the number of inquiries in regard to water supplies was much larger.

The results of the tests made are given in the following table:

WATER SAMPLES EXAMINED

Source	Reported as Safe	Reported as Bad	Total Number of Samples
Deep wells (drilled)	4	6	10
Driven wells	6	3	9
Dug wells	3	6	9
Springs	1	2	3
Unknown	9	14	23
Total	23	31	54

Examination of three swimming pools in nearby cities was made and the results obtained indicate the need of regulations by State legislation. Several states have laws regulating the care and construction of swimming pools.

In two of the pools examined no bacteriological examinations are made at all and in the third the examinations are extremely irregular. Furthermore, one of these pools has received no treatment and the water is used for long periods. Such conditions are unnecessary and further, are very dangerous.

The results obtained from the examination of the College swimming pool show very conclusively that a swimming pool must be checked constantly by bacteriological procedure. The College pool has been examined daily during the school year. I wish to again repeat that the system of chlorination is very unsatisfactory and should be replaced preferably by liquid chlorination.

Two disinfectants were submitted for examination. Both of them failed to show any germicidal value even when full strength was used.

[W. L. MALLMANN.]

I wish to thank you in behalf of myself and all the members of the Bacteriological Section Staff for your invariable courtesy and helpful spirit in all our mutual undertakings.

Respectfully,
WARD GILTNER,
Bacteriologist.

REPORT OF THE SECTION OF BOTANY.

To the Director:

Sir:—The work of the Botanical Section of the Experiment Station has been prosecuted with great zeal by the members of the staff who deserve commendation for their interest in the work and the time they have put into it, far beyond the ordinary accepted office hours. The following changes in the staff for the past year may be noted:

Mr. H. C. Young, Research Assistant in Plant Physiology, was granted a leave of absence to accept a fellowship for the investigation of the fungicidal properties of sulphur, established by the Plant Protection Institute and located at the Missouri Botanical Garden.

Mr. Ray Nelson, Research Assistant in Plant Pathology, was given a leave of absence beginning with the middle of November to undertake graduate work at the University of Michigan.

Miss Miriam Carpenter was appointed Half-time Graduate Assistant in Plant Pathology.

Dr. R. P. Hibbard, who had been for ten months at Johns Hopkins University co-operating with the Department of Botany there on certain important plant nutrition experiments returned to work July 1, 1922.

Owing to the very inadequate greenhouse space available, it was necessary to rent part of a greenhouse in Lansing to carry on some of the important pathological work on celery diseases and some on potato disease work. It is to be hoped that adequate greenhouse space may be available for the pathological and physiological work of the Botanical Section as the lack of this is crippling the work badly.

It is to be regretted that it has been impossible to have an Extension Plant Pathologist appointed. Such a man would take care of a large portion of the correspondence and much of the travel throughout the state which must be carried on by Dr. Coons and the pathologists associated with him, in the absence of an Extension Pathologist.

My work has been mainly that of consultation with Dr. Coons with reference to plant pathology work, and with Dr. Hibbard with reference to work in plant physiology. At the limited season of the year when the living spores are available, I have for two years carried on investigations upon the rusts of blackberries and raspberries.

I am appending herewith, and request that they be made a part of my report, the reports of Dr. Coons on the plant pathological investigations and of Dr. Hibbard on the plant physiology investigations.

Very truly yours,
E. A. BESSEY,
Professor of Botany.

Dr. E. A. Bessey, Professor of Botany, M. A. C.:

Dear Dr. Bessey:—I herewith submit a brief report of the work in Plant Physiology for the year ending June 30, 1923.

After a leave of absence of ten months at the Johns Hopkins University, I returned on July 1, 1922, to take up the work at M. A. C. In the absence of Mr. H. C. Young, who spent the present year at Shaw Botanic Gardens, St. Louis, Missouri, his problem on "The Physiological Effects on Life Processes of Certain Plants When Growing Under Deficient or Improper Nutritive Conditions" was discontinued.

Mr. Paul Tilford, a senior student, assisted me as time allowed, in both the experimental and the college work, and I wish to draw attention to the fact that his work was excellent.

The work in Plant Physiology has been divided between the College and the Experiment Station. In the absence of Mr. Young and other assistants, the college work has required more time. Further, the apportionment of time this year has been approximately two-thirds for the College and one-third for the Experiment Station.

Adams Project:

The Adams 2f project was continued, but work this year was carried on entirely in the laboratory and the greenhouse. Field work, as conducted in former years, was entirely out of the question in view of the scarcity of funds. In the laboratory and greenhouse chief emphasis was placed on a study of the influence of climatic conditions on the salt ratio requirement of Marquis wheat. Two climatic conditions were studied, and in this respect the natural conditions were called into use. The first experiment was run in the early fall—September and October, and the second in late spring—May and June.

My previous work had shown that for different climatic conditions a different salt ratio was required. This difference seemed to be ascribable to the variations in light duration and intensity during different experimental periods. The results of the experiments this year, however, do not bear this out, for the same cultures that were best during the September-October period remained the same high-yielding cultures for the May-June period. The conclusion is inevitable; some other unknown variable is acting as a limiting factor. As in former years this problem continues to be interesting. As new vantage points are won, others have to be attacked. Much progress has been made by different investigators, and the work that I have done here and at Johns Hopkins has brought out certain definite facts:

1. No definite results that will stand statistical treatment can be obtained with few plants in a culture. Tables have been devised showing what significance can be ascribed to cultures containing plants numbering from 10-100. It has now been determined that from 40 to 50 plants should be used for each salt solution.
2. With frequent changes (every other day) and with a lower total condensation (1 atmosphere) the plants thrive better than ever before.
3. Pure line seed, or seed of a single plant selection, give more uniform seedlings.
4. Special methods for germination were devised. Through this means more uniform seedlings were obtained.

It is interesting to find that after using the above methods, more consistent results are obtained. For example, heretofore no definite combination of salts seemed to be necessary for plant growth. The ratio of salts could vary quite widely without affecting the yield. Now it is evident that there is a best culture, and a certain definite region on the triangular diagram that shows this. The other cultures grade away gradually on all sides. This kind of arrangement is expected from the nature of grouping of the cultures on the triangle. In all previous work the good-yielding cultures have been scattered over the triangle. Most disconcerting of all duplicate series would not check, culture for culture. A series repeated later would not agree, and so very conflicting results were obtained. I believe that the use of a large number of plants is a great factor in bringing about the good results obtained in the past two years.

Horticultural Project:

This project was outlined as a co-operation between the Department of Horticulture, the Department of Soils, and the Department of Botany about four years ago. At the beginning of the present year, the co-operation was somewhat modified due to the changes in the Horticultural Department, and at present the co-operation is between the Departments of Horticulture and Botany. The outline, somewhat changed from its original form, is appended. The items starred are those being studied in the Botany Department. Work has been pushed along all lines, but especially in the study of carbohydrate synthesis and utilization.

The methods used in our former studies did not seem to give consistent results, so during the winter the old methods were modified and better results are now being obtained. The H ion studies of buds and spurs were deferred until next year in hopes that by that time a reliable method could be devised for determining the hydrogen ion concentration. The project is still to be continued through the summer and fall. During the spring no trips were made to this experimental orchard at Grand Rapids because of lack of funds; but trips were made to a nearby orchard which had received the same treatment. A detailed report on this project can not be expected this year.

Quinlan Orchard Project. (Grand Rapids.)

1. What is the influence of the different fertilizer treatments on the size and number of leaves per spur?
*2. What is their influence on the rate of carbohydrate synthesis per unit of leaf area?
3. What is their influence on summer defoliation?
*4. What is their influence on the total carbohydrate accumulation in the spurs in the fall?
*5. What is their influence on the rate of carbohydrate utilization (as measured by amounts present at successive intervals during and after blossoming) in the spring?
*6. What is the influence on H ion concentration in the spurs from week to week throughout the season?
7. What is their influence on the percentage of spurs blossoming each spring?
8. What is their influence on the setting of the fruit?
9. What is their influence on the yield?

*10. What is their influence on the osmotic pressure of the leaves and the spurs?

National Research Council Project:

We regret that the lack of funds required us to drop this projest this past year. We hope that before long this co-operation with the National Research Council can be renewed.

Soil Temperature Project:

In co-operation with the Ecological Society of America the Michigan Experiment Station has been gathering soil temperature data for the past five years. Since this work did not require much money or time it was continued as usual.

Very sincerely yours,
R. P. HIBBARD,
Plant Physiologist.

Dr. E. A. Bessey, Professor of Botany, M. A. C.:

Dear Sir:—I wish to submit the following report of progress on the various projects in Plant Pathology under my immediate charge.

Adams Project 5b:

On this project which has to do with determining the various biological reactions of plant pathogens of the Sphaeropsidales group, work along the lines of methodology has been carried on rather intensively so long as animals and space were available. The work is carried on cooperatively with Dr. Stafseth of the Bacteriological Department and has dealt with the development of precipitins by the use of fungous cultures prepared in various ways. In general, summarizing the results of many tests with rabbits, it may be said that the development of precipitins capable of giving a strong decisive precipitate or clouding by use of ground cultures is not promising because of several factors: (1) the low percentage or protein in the mycelial mat used, (2) the difficulties inherent in the grinding and preparation of the mycelial mat, and (3) the loss of experimental animals through anaphylactic shock during the later injections.

From results obtained with closely allied fungi it is very evident that serum reactions will differentiate the fungi readily. The problem then resolves itself into one of development of methods. With the establishment of a fixed routing it will be very easy to make several very important applications of this method of diagnosis.

Along another line of attack considerable progress has been made by the use of dyes as a means of differentiating related organisms. This work which is being carried out under my direction by Miss Miriam C. Carpenter gives promise of making dye utilization in the study of fungi as useful a tool as it is in the study of bacteria.

Hatch Fund Projects:

Under this head various minor investigations are carried on. Work on the plant disease survey which aims to determine the distribution of plant pathogens in the state and their severity in causing crop loss has been carried on under this head. The reports of plant disease occurrence, etc., have been made to the central, federal office.

State Projects:

Celery Disease Investigations.

Work on celery diseases has confined itself to development of the yellow-resistant celery. Some 400 plants of known parentage were tested in the field and found resistant to the disease. These plants were brought through the winter in the greenhouse and are now producing seed. Progenies from the original selection made in 1919 are now being tested as to quality and type. From this set of plants will be selected the best commercial strain, and then the seed will be released through the ordinary channels for general use. The work is handicapped by lack of greenhouse facilities and much valuable time in the increase of seed stock is being lost. For three years the yellow-resistant seed has produced fine plants in disease-infested soil either at Kalamazoo or Mason, Michigan.

Bean Disease Investigations:

Investigation of bean diseases has been restricted to two lines of work: (a) work of testing of bean hybrids for Anthracnose resistance, and (b) investigations of Bean Mosaic.

(a) The first line of work has been carried out in co-operation with the Farm Crops Department and consists of testing various new strains of beans derived by crossing Red Kidney beans (Wells) with Robust beans. These have been subjected in field and greenhouse to various strains of Bean Anthracnose and all those proving susceptible to attack have been rejected. About a dozen beans of very resistant type are now being studied by the Crops Department for yield and the tests with organisms are being continued. This work is carried on by the writer.

(b) The other phase of bean disease investigations carried on at the station consists in work on Bean Mosaic by Ray Nelson. In this work Mr. Nelson has sought to throw some light on the cause of mosaics—those obscure diseases about which there is so much that is unknown and baffling. By cytological investigations, Mr. Nelson found certain heavily staining bodies in the phloem of diseased plants and he interpreted these to be protozoa, presumably the casual agents in disease production. Further work with other plants than beans has failed, so far, to confirm this interpretation and more work is needed to clear up this problem. Mr. Nelson has been on a year's leave of absence working for an advanced degree at the University of Michigan.

Potato Disease Investigations:

This work has, as in the past, consisted of certain field trials carried on jointly by Mr. J. E. Kotila and the undersigned and in investigations of the black-leg disease carried on by Mr. Kotila.

Experimental fields have largely been located at the Upper Peninsula Experiment Station at Chatham, where interesting results on the use of sulphur for Scab control have been obtained. In field tests the relative values of spraying and dusting for hopper burn and fungous disease control have shown marked superiority of the Bordeaux spray.

In co-operative work with the Farm Crops Department hundreds of potato tubers have been indexed and fields have been rogued in an attempt to clean stock from disease and permit the development of disease-free seed stock for increase by farmers. This work gives great promise with certain varieties but disease elimination in some strains is very difficult due to masking of symptoms.

Black-leg investigations have concerned themselves with studies on the severity of the disease, the effects of treatment in control and agencies of dissemination. The results are now being prepared for publication.

Cereal Disease Investigations:

Work on cereal diseases has been carried on by the writer and has consisted of tests of various fungicides for Stinking Smut control and tests of disease resistance of certain varieties. The new copper dust methods for seed treatment have been tested over several seasons and have been used rather extensively over the state. With fairly clean grain, the dusting method gives great promise.

Far more important than the results obtained by specific treatment is the evidence which several years of test have given that certain hybrids of various high yielding wheats are immune to Stinking Smut. In particular, hybrids with Berkeley parentage seem to be immune to Stinking Smut in spite of heavy (artificial) seed contamination.

Seed treatment as a method of Stinking Smut control will always be a readily applied method in the hands of the farmer who is willing to take the trouble to prevent loss. But, if high yielding, smut-resistant varieties can be developed, then this wasteful disease will cease to be a factor at all in Michigan's wheat crop.

Small Fruit Disease Investigations:

In May, 1922, Mr. C. W. Bennett was transferred from full-time College work to full-time Experiment Station work. His investigations have confined themselves largely to raspberry diseases, especially diseases of the mosaic type. He has carried out extensive rogueing tests in the small fruit producing counties of the state and has demonstrated the relation of aphids to disease dissemination.

Publications:

The following publications have been issued during the year:

1. Kotila, J. E. Leaf Hopper Injury to Potatoes. Mich. Sta. Tech. Bul. 56, 27 pp.
2. Kotila, J. E. Spraying for Hopper-burn. Mich. Sta. Circ. 48, 4 pp., July, 1922.
3. Bennett, C. W., Loree, R. E. and C. W. Bennett The Raspberry Situation in Michigan. Mich. Sta. Quart. Bul. 5:31-33, August, 1922.
4. Coons, G. H. Copper dust treatment for Stinking Smut. Mich. Sta. Quart. Bul. 5:8-11, Aug., 1922.
5. Nelson, Ray. Transference of the bean mosaic virus by *Macrosiphum solanifolii*. Science 56:342-344, Sept. 22, 1922.
6. Nelson, Ray. The occurrence of protozoa in plants affected with mosaic and related diseases. Mich. Sta. Tech. Bul. 58, 28 pp., Dec., 1922.

7. Coons, G. H. Control of Stinking Smut of wheat (*Tilletia levis*) with dust treatments. Phytopathology 13:37. Jan., 1923.
8. Kotila, J. E. and G. H. Coons. Spraying and dusting of potatoes in 1922 at Chatham, Michigan. Phytopathology 13: 54-55, Jan., 1923.
9. Bennett, C. W. Apple scab and its control. Mich. Sta. Quart. Bul. 5:130-134. Feb., 1923.
10. Kotila, J. E. Mosaic and potato yields in Michigan. Mich. Sta. Quart. Bul. 5:188-189. May, 1923.
11. Baxter, Dow V.* and G. H. Coons. White pine blister rust in Michigan. Mich. Sta. Quart. Bul. 5:193-196. May, 1923.
12. Coons, G. H. Celery blight or leaf spot. Mich. Sta. Quart. Bul. 5:190-193. May, 1923.
13. Kotila, J. E. and G. H. Coons. Trypanosome-like bodies in solanaceous plants. Phytopathology 13: July, 1923. (Inpress.)

---

*Collaborator, U. S. Dept. of Agr..

Respectfully submitted,
G. H. COONS,
Plant Pathologist.

REPORT OF THE SECTION OF CHEMISTRY.

To the Director:

Sir:—The following report briefly summarizes the work of the Chemical section for the year ending June 30, 1923:

CHANGES IN THE STAFF.

Miss S. L. Bandemer severed her connection with this section at the close of the last fiscal year. Arthur W. Lowell, a graduate of the University of Maine in 1921, was appointed on October 1st to fill the vacancy. Mr. H. A. Noyes was appointed on December 1st to take charge of the work in connection with the new cereal project approved by the Board of Agriculture in October. Mr. Noyes remained with us only three months, resigning March 1st to accept a much more lucrative position. No successor to Mr. Noyes has been appointed.

Mr. E. J. Miller was granted leave of absence from March 1st to June 1st for the purpose of completing his graduate work at the University of Michigan. The degree of Ph.D. was conferred on him at the Commencement, June 18th.

ADAMS FUND PROJECTS.

Adams 2b.—"A study of the physico-chemical aspects of soil acidity." Two papers on the nature of adsorption of electrolytes from solution by activated sugar charcoal have been published in the Journal of the

American Chemical Society, and a third paper dealing with the theory of hydrolytic adsorption is being prepared. The data in these papers clearly indicate (1) that hydrolysis is an important factor in adsorption, (2) that there is a close relationship between adsorption and chemical constitution, and (3) that the erroneous and contradictory results found in the literature are due to impurities in the reagents used.

Experiments with fuller's earth and kaolin, carried out in the light of the knowledge gained in the charcoal adsorption studies are yielding interesting and significant results.

Adams 2 ba.—"A study of the organic compounds in peat soils." The work has been carried on along the lines planned last year, but the collection of material for this work was not completed because of inability to locate deposits containing certain types of peat. It is hoped to complete the collection of samples at an early date when active work will again be started on the project.

HATCH FUND PROJECTS.

"The preparation of neutral ammonium citrate solutions." This project has been completed. The final results obtained were published in the Journal of Official Agricultural Chemists, Vol. 6. p. 384. The method for the preparation of neutral ammonium citrate developed under this project has been adopted by the Association of Official Agricultural Chemists and at the next meeting it will be made the official method of the Association.

"A study of the availability of organic nitrogenous substances." Considerable work has been done during the year and a modification of the method now being used for determining the availability of organic nitrogenous substances is being prepared for publication. The project will be continued as outlined.

"Michigan Wheats and Flours." Twenty-one samples of wheat representing the more important commercial varieties grown in Michigan were supplied by Prof. Spragg. These were analyzed and ground into flour. The flour was then analyzed and tested for baking quality. The protein content of the wheat varied from 9.82 per cent to 14.00 per cent and the protein content of the flours from these same wheats varied from 8.98 per cent to 12.65 per cent. The baking tests were conducted by Mr. O. B. Winter and very marked differences as to bread making properties were demonstrated. This work will be continued and greatly amplified during the coming year.

MISCELLANEOUS.

A great deal of work has been done for other sections of the Station during the year, which is briefly summarized as follows:

For the Farm Crops section—Two hundred samples of sugar beets. These were tested both as to sugar content and purity of the juice.

Two samples of potatoes, one from a normal hill and the other from a hill infested with "giant hill" disease.

Nine samples of sunflower silage grown at the Upper Peninsula Station. Twenty-five samples of flax were analyzed for total ash, soluble and insoluble silica.

Twelve samples of corrosive sublimate solution used in treating seed potatoes were analyzed to determine the effect of successive treatments upon the strength of the solution.

For the Soils section eighteen soil samples were analyzed.

For the Animal Husbandry section three samples of corn fodder and silage were analyzed, and for the Botany section ninety samples of sugar beets were tested.

Forty samples of soil taken in connection with the Land-Economic Survey of Charlevoix County, conducted by the State Department of Conservation, were analyzed. In addition, Dr. Robinson spent about two weeks in the field assisting with the peat survey of the county and also co-operated in preparing the report on this phase of the subject.

Twelve samples of commercial flour from Michigan mills were analyzed and tested as to baking qualities. The best flours were those that had a certain amount of hard spring wheat blended with the softer winter wheat.

In addition, seventy-six samples of a miscellaneous nature submitted by residents of the State were analyzed. Collaborative work for the Association of Official Agricultural Chemists was done on methods of analysis for crude fiber, insecticides, sulfur in organic materials and ash constituents of plants.

In conclusion, I desire to acknowledge my gratitude to members of the staff for their hearty and loyal co-operation in the work of the section, and to you for your advice and support throughout the year.

Respectfully,
ANDREW J. PATTEN,
Chemist.

REPORT OF THE SECTION OF ENTOMOLOGY.

To the Director:

Sir:—The present fiscal year has witnessed no changes in the personnel of the section of entomology. However, at the end of this fiscal year, June 30, Dr. W. L. Chandler will be transferred to the Department of Bacteriology. The projects in parasitology will henceforward be carried on by the Department of Bacteriology and microbology in the Veterinary Division.

THE GREEN PEA APHIS.

Illinoia Pisi

The summer of 1922 was notable for the prevalence of the pea aphis (*Illinoia pisi*). On June 13, 1922, a trip was made in company with Mr. Harman, Extension Specialist in this department, to Kent City to view the fields of canning peas with Mr. J. Hackley Skinner, Agriculturist for the Roach Canning Company, and Dr. Chas. Woodbury, National Canner's Association. The fields were very badly infested and several tests of dusts were made with a large power duster. However, it seemed a question whether the dusting paid in this case since the vigor of the peas had already sunk so low that the increased yield was hardly expected to pay for the application. The figures show the appearance of louse infested plants and also a healthy pod compared with one injured by lice. At the time of harvest the effect of the infestation was clearly demonstrated.

On November 9th and 10th a conference of entomologists and others interested in the business of pea culture was held at Chicago where the whole question was discussed and experiences exchanged, after which a plan for co-operation was outlined. Representatives from California, Alabama, Wisconsin, Minnesota, Michigan, Indiana, Illinois, Maryland, New York and Ohio being present at this meeting, the following fact seems to have been demonstrated viz.—"that the cost per acre of large spraying operations is from $3.50 to $6.00 per application, including cost of material, labor and depreciation of machinery, and aphis control will require, under ordinary conditions at least two applications. The expense of dusting, based on present data and costs of materials, is slightly higher than that of spraying. The speed with which dusting may be done, however, is much greater, and this counts in cases of emergency.

On May 9, 1923, the Insect Pest Survey of the Bureau of Entomology, reported in special report number 25, the presence of the pea-aphis seriously injuring alfalfa from Kansas City to Boonville, Missouri. This report was turned in by Professor Haseman of Missouri.

On the receipt of this report the writer computed, by means of the number of isophanes intervening between Kansas City, Missouri and

Grand Rapids, Michigan, about when such an appearance might be expected in Michigan, should the aphis appear at all in numbers.

No corrections were made for elevation above sea level, the computation being made rather loosely. I will say that this computation was based on the work of Dr. A. D. Hopkins of the Bureau of Entomology, whose investigations on the progress of the seasons from the south to the north is our standard source of information.

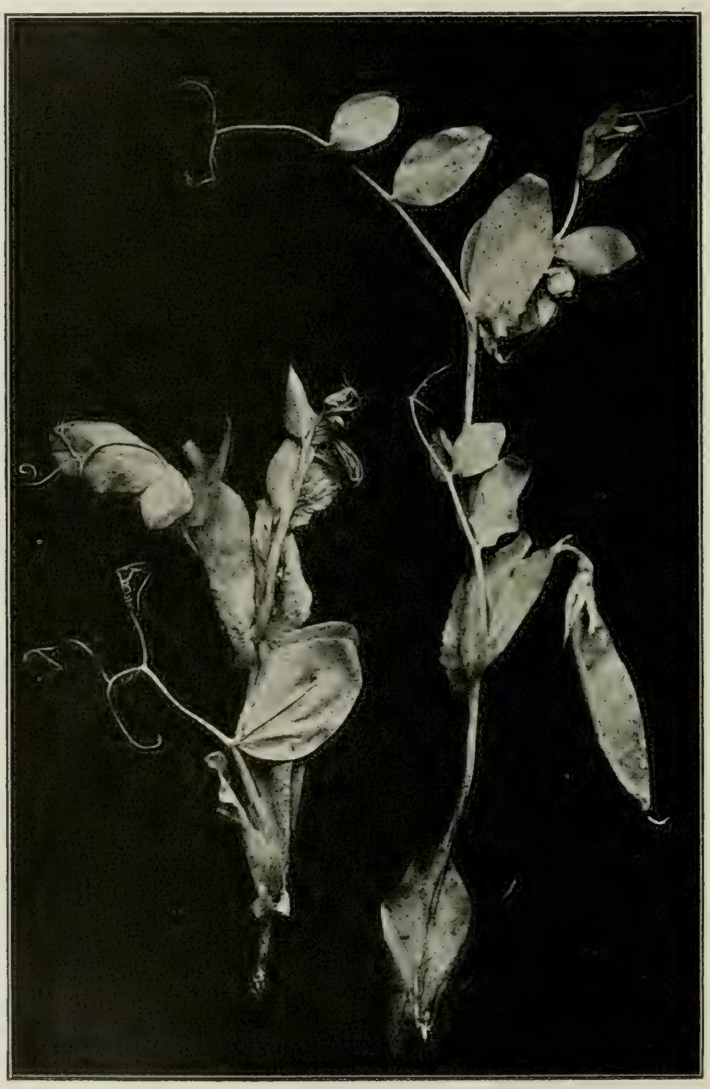


Fig. 1—Healthy pea plant compared with one injured by pea-louse

It would appear from these computations that we might expect a similar development at the latitude of Grand Rapids and Kent City where many canning peas are grown, on about Decoration Day. Furthermore, no corrections were made for the influence of large bodies of water.

It is interesting to note that on the 22nd of May the pea-louse was

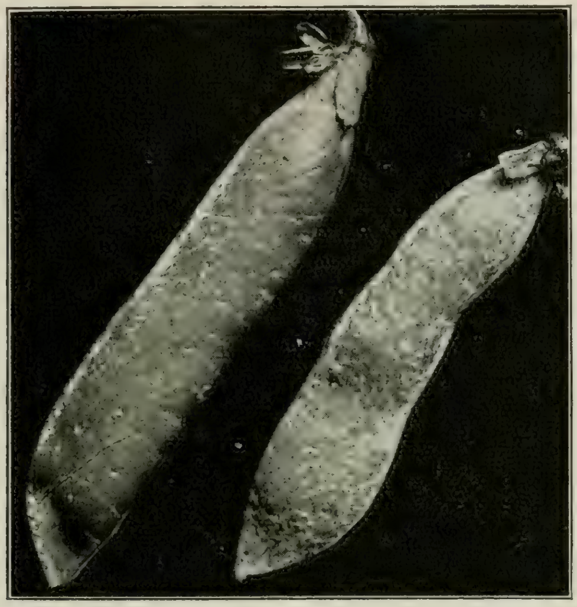


Fig. 2—Healthy pea pod compared with one injured by pea-louse

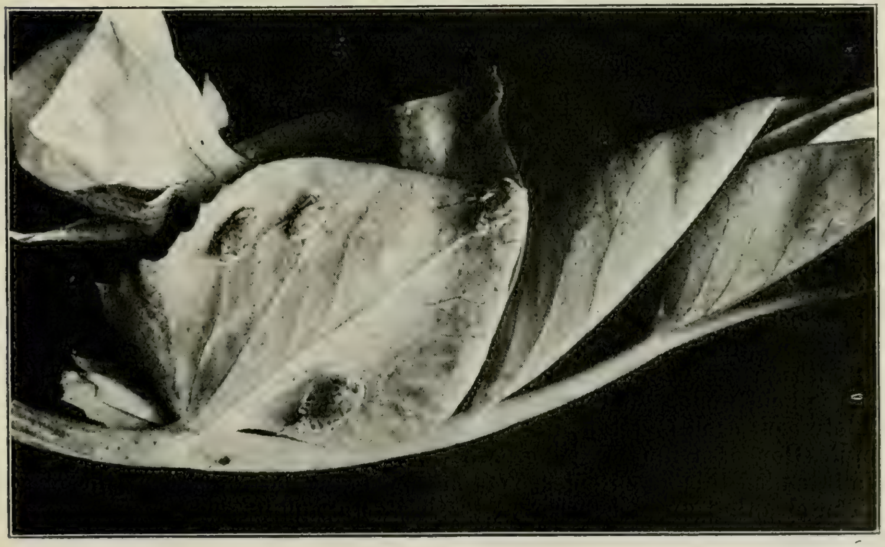


Fig. 3—Green pea-louse killed by fungus disease Empusa aphidis on pea

reported at Cassopolis, Michigan. Specimens were sent in, which left no doubt as to the identity of the louse. On the 26th of May we received specimens from Allegan and on the 25th from Paw Paw, where the louse appeared in enormous numbers on alfalfa and threatened the life of the plants. On the 1st, inst. (1 June) Mr. W. R. Roach of the Roach Canning Company, Grand Rapids, informed us by telephone that the lice were present at Kent City and vicinity in great numbers. Thus our conclusions as to the rate of progress of the season appear to be justified.

Now, as tot he seriousness of the attack. On the 1st day of June, we were informed that on the 26th and 27th of May, the number of lice had noticeably decreased in the Paw Paw region, and in connection with this it is interesting to note that Mr. John Harman, Extension Specialist in this department, reports, after a visit to several places in the region of Paw Paw and Cassopolis, that the dwindling of the lice was apparently aided by four agents, namely: a large number of ladybirds, two species of hymenopterous parasites, one of which is *Lysiphlebus,* and to a fungus disease which we identified as *Empusa aphidis.*

Of course, the onslaught by the natural enemies of this pest was favored by the weather which had in the meantime become warm and summery, it having been, previously, quite cool, the season being backward.

The appearance of the pea-louse in our alfalfa fields exactly at the time computed appears significant.

GRAPE BERRY MOTH,

Polychrosis viteana.

The summer of 1922 witnessed the most serious outbreak of grapeberry moth that has ever occurred in Michigan, since our grape belt took its place among the real producers.

The life history of this insect must be somewhat variable. We believe that three generations occurred, all of which overlapped noticeably. The pupal stage should be passed in little flaps cut in the leaves but careful search failed to reveal more than a very few such flaps. This led us to suspect the presence of the European species. However, all specimens bred from the grape belt proved to be the common American species.

Our recommendations provided for a spray just before the blossoms open, another when the fruit is nicely set, and another spray just before the grapes closed in the cluster, as late as possible before most of the berries touch and become tightly packed in the cluster. We also recommend that the spray be shot upward from below under good pressure and with liberality. This is possible only when the spraying is done by the trailer method, that is,—when a man follows the spray rig with an extension and a nozzle set at right angles to the extension. This is held under the fruit and the spray is shot upward so as to completely coat each bunch of developing grapes. We also recommended the application of a fourth spray, two weeks after the one just mentioned. We intended this as an emergency measure and not for general practice.

The cleaning up of brush and trash was strongly recommended since the injury was uniformly the worst on the borders of vineyards. This also helps ot control the leafhopper which was present in large numbers.

Now, the little flaps in the leaves in which the pupal stage is passed fall out and lie on the ground during winter and the advantage to be gained by early plowing under of leaves and the cover-crop is easy to be seen. We, therefore, recommended that the cover-crop be sowed early enough so that it could get its growth in the Fall and be turned under early in the Spring. This, we believe, will destroy many pupae.

The spray generally used was arsenate of lead at the rate of one and one half pounds to a barrel of bordeaux with a pound of resin fish oil soap added for a sticker. It was recommended that 300 gallons to the acre be applied under high pressure.

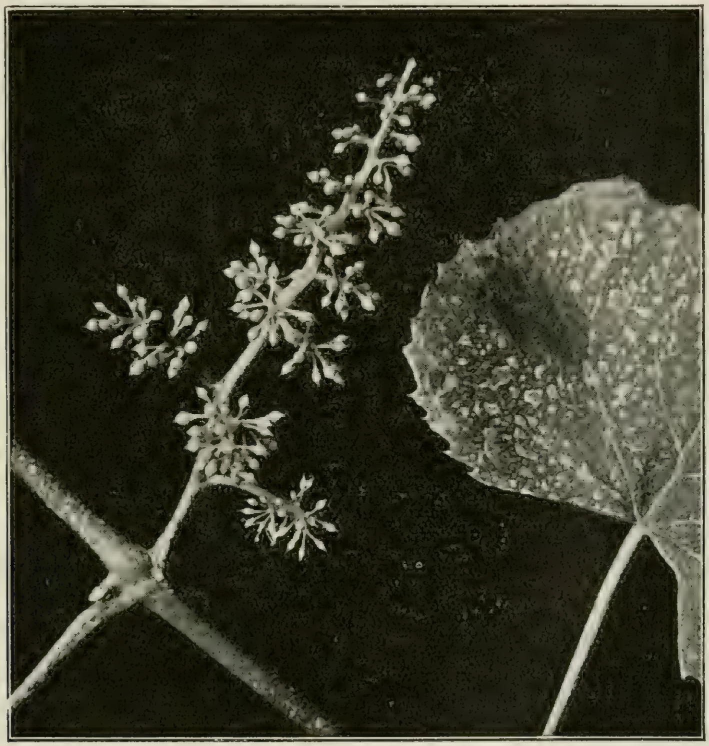


Fig. 4—Grape-berries just set. Blooming period completed. Time for second spray

An inquiry into methods used in individual vineyards after picking time, clearly showed the superiority of the follow-up method over a spray put on with a boom rig. It also indicated the superiority of four sprays, the loss in some vineyards so sprayed being often less than 7%. The vineyards sprayed by the boom method and with a less number of applications, lost sometimes as high as 95%. This was exceptional however, the loss over the entire vineyard usually being under 50% except on the borders of the vineyards.

In general it may be said that the best results were obtained when hand-spraying was done by the trailer method and the best of all when the application was most liberal. We were greatly assisted in this work by Mr. W. C. Eckard, County Agent for VanBuren county. Without his understanding and untiring effort the loss this year would have been far greater.

CHINCH BUGS.

A severe attack on corn was made by chinch-bugs in the southern tier of counties in 1922, and in response to a call for help, Mr. Harman, Extension Specialist in this department, conducted a successful campaign aided by Mr. H. G. Putnam, a recent graduate of Michigan Agricultural College, the two working in co-operation with the County Agents.

The adult chinch-bugs pass the winter in clumps of grass, under fallen leaves, and rubbish, and wherever protection from the weather may be had. In the spring they fly to fields of wheat where eggs are laid. The young bugs, when hatched, suck the sap from the young wheat plants, causing serious losses in the wheat itself. After the wheat begins to ripen, the bugs start out on foot to reach corn fields, often almost covering the ground, so great are their numbers. They finally climb up into the corn, and attack the fresh, green plants. The bugs work even more deeply into the fields until there is no hope for the crop. Here a new generation of bugs is produced, the adults of which pass the winter in grass and rubbish, as did the first ones noted.

The greatest damage in Michigan is done when the bugs attack the corn, and if the owner can stop the progress of the bugs before the corn is attacked, or at least before they get beyond the first few rows, he can usually avoid serious damage. Only a few of the bugs of the summer generation fly, the swarms traveling on foot to invade the corn, and therefore a barrier placed between the grain fields and the growing corn serves to protect the corn for the time being.

Various types of barriers are used in chinch-bug infested regions, but the one most successful under Michigan conditions seems to be the one used extensively during the invasion of 1922, and described by Mr. J. H. Harman as follows:

"First—Drag a weighted plank, ten or twelve inches in width, across the line of advance. This forms a smooth path on which to lay tar. If the chinch-bugs have advanced into the corn it is well to lay out the path a few rows ahead of the line of infestation.

"Second—In the center of the path dig a series of post-holes twelve inches deep and twenty to thirty feet apart. Be sure to bevel the rims of the holes.

"Third—Lay down a line of tar about an inch in width on the side of the path farthest from the advancing bugs, being sure that it touches the rim of each hole. As the bugs advance to the tar line they will not cross, but will start along parallel to it in an effort to find a place to pass over. As they reach the holes they pass over the rims and fall to the bottom.

"Fourth—In the bottom of each hole place about two inches of hydrated lime and dust it around the sides about half way up. The insects falling in the lime cover themselves with the dust and soon suffocate. It is well to visit the holes once a day and stir the lime. When the insects are numerous one should renew the lime every three or four days or oftener as the case may demand.

DUST MULCH CONTROL OF CHINCH BUG.

"The dust mulch barrier is a complete barrier to the migrating chinch-bug where the soil is sandy. If there is any great amount of clay with the sand, it forms clods and will not break down fine enough to be of use.

"Select the location where you are to construct the mulch barrier, figuring on a path six or seven feet in width.

"When the time of migration approaches, plow a deep furrow down the center of the path, throwing the earth toward the insects. Plow back in the same furrow, throwing the earth away from the insects. Procure a log about twelve or sixteen inches in diameter and about five or six feet long. Hook a team to the log and drag it back and forth in the furrow. This rubs up the lumps and keeps the sand loose and soft. The bugs will fall into the trench but can not crawl out.

"Where the soil is well dried out and easy to pulverize it will require dragging only about twice daily. This daily dragging will kill any bugs in the trench."

Destruction of the hibernating adults in their winter quarters, in permanent control work, can be accomplished most easily by fire. The bugs hide away in grass tussocks, under fallen leaves, in brush piles, under shocks of corn, and in fact in any place where shelter from too sudden freezing and thawing may be had.

GRASSHOPPERS.

The grasshopper situation is improving steadily in the parts of the state first attacked. The hoppers spread slowly around the edges but natural enemies are multiplying at such a rate that we look for a return to normal in the older infested areas with a gradual dying out of the pests on the border.

This will naturally be succeeded in time by a new outbreak after a few years, since the large areas of cut-over land, and land not under cultivation, offers very favorable conditions for grasshoppers, whenever there are dry seasons.

The Upper Peninsula is still badly infested, the natural control has not progressed so far as in the upper half of the Lower Peninsula. One must still feed the pests on poisoned baits in order to help restore normal conditions.

THE BEAN-WEEVIL.

For several years the number of bean weevils, *Bruchus obtectus*, sent in to this office has been increasing. An inquiry into the matter leads one to believe that the beetle is not uniformly distributed over our state but that it is quite local in its distribution. It is also a fact that Michigan easily leads all other states in the production of white beans.

It was, therefore, deemed worth while to carry on something of a campaign against this pest which is beginning to make itself felt in the market. Michigan beans have heretofore enjoyed the reputation of being clean and free from weevil.

Some attempt has been made to spread the gospel of clean seed, and to urge growers to fumigate their product whenever weevil appeared. This movement has been greatly facilitated by the manufacturers of carbon disulphide who are willing to supply moderate quantities of a very good grade of this fumigant at between six and seven cents per pound which is a fraction of the price ordinarily paid to the retail dealers.

Thus far the elevator men and the big growers have taken very kindly to the idea and are willing to go to some little trouble to maintain our previous high standard of quality.

THE THREE-BANDED GRAPE LEAFHOPPER.

The three-banded grape leafhopper (*Typhlocyba tricincta*) was plentiful in the grape belt but the spray of bordeaux and nicotine sulphate was timed just right by a large proportion of the growers with very gratifying results. The most effective applications were put on just as the members of the first brood were about to acquire wings. Of course some of the individuals were still in the egg stage but it seemed as if the spray prevented some (at least) of these eggs from hatching. At any rate the loss from leafhoppers was considerably less than the loss during the year before, in spite of the fact that the season started with an abundance of over-wintering adults.

POTATO LEAFHOPPER IN ALFALFA.

Leafhoppers in alfalfa appeared in very small numbers during the latter part of the summer of 1922. No adequate control was found. All sprays and dusts seemed too expensive to warrant their use. The species proved to be the common form on potato (*Empoasca mali*). This unusual attack accentuates the desirability of burning all rubbish and fallen leaves, which collect in fence-corners, around hedges and like places late in the fall,—thus destroying the hibernating quarters of the over-wintering hoppers, together with many other noxious pests.

PARADICHLOROBENZENE.

Paradichlorobenzene is coming into pretty general use against the peach-tree borer. It is proving to be a safe and effective agent, and has one very valuable attribute viz., by its use one can avoid the operation of "worming" peach-trees with its very real hazard of carrying the infection of crown-gall from tree to tree on the tools employed. This consideration alone should recommend the use of the chemical treatment very strongly. The writer has witnessed the spread of crown-gall from a few trees to an entire peach orchard merely by using an unsterilized knife on tree after tree in removing the larvae from about the crown.

TERMITES.

Leucotermes flavipes.

Every year seems to impress on us the conviction that white-ants (termites) are not confined to southern localities but that they are finding in Michigan suitable homes.

At present we are trying to find a way to save a large cherry orchard and a fair-sized peach orchard in Oceana county. These orchards are set on ground formerly used for orchard purposes and many stumps are present.

The termites work from their nests in the old stubs to the young trees, feeding on the otherwise healthy young roots and finally riddling them.

A treatment of paradichlorobenzene succeeded in driving the termites down to a point where the gas did not reach them and also in some injury to the young trees.

At present the old stumps are being taken out with dynamite and small nests will be treated with carbon disulphide.

BORER REPELLANT.

After a search covering a period of twenty-five years the writer has at last found a dressing which serves fairly well as a repellant against the flat-headed borer and which undoubtedly will prove as effective against other borers as well. During 1922 the formula stood as follows:

Common laundry soap	50 pounds
Water	3 gallons
Flake naphthaline	25 pounds
Flour	2 pounds

Place the soap in the water over steam-pipes and allow it to soften for a few days. Use a potash soap which will form a smooth mixture, not a soda soap since the latter becomes jelly-like. Then place in a double boiler (we use a medium-sized wash-boiler placed inside a very large one) and cook until the temperature reaches 180° Fah., stir in the flour and add the naphthaline and bring the temperature to 180°, at which temperature the naphthaline will have melted, the melting point of naphthaline being 176°, then cool as quickly as may be, stiring the mixture occasionally.

The more rapidly the mixture is cooled the smaller will be the crystals of naphthaline.

In our experimental work this mixture was made up during the winter and stored in air-tight drums. It should be applied with a brush after warming and thinning slightly to the consistency of heavy cream. In our trials applications were made three weeks beginning June 1st, and in no case thus far has any injury to the trees resulted. At the same time almost no flat-heads have been found in trees so protected although they abounded in the checks and in some cases had done very serious injury to young trees in the same orchards previous to the application. Our tests have covered a period of about four years and have been made on several thousand trees.

It seems likely that it will be possible to extend the interval between treatments without losing a reasonable insurance against attack and perhaps the same treatment will protect from other borers of the trunks and limbs of various trees.

CODLING-MOTH SERVICE.

The experiment dealing with the setting of the date for the August spray for the second generation of codling-moth has developed into a regular service. The plan seems to work out well enough so that the apple growers who depend on our data are satisfied and convinced that

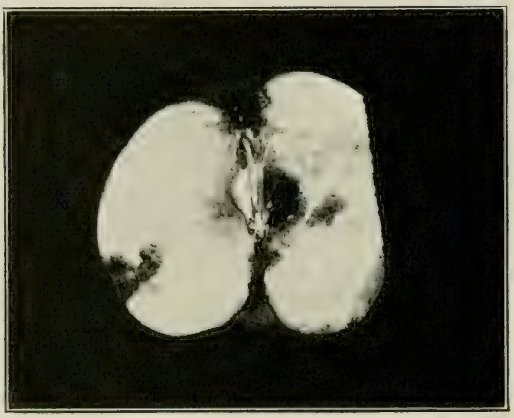


Fig. 5—So-called "side-worm" work, due to codling moth
The apple was entered late in the season, but the larva either died or stopped work before penetrating deeply.

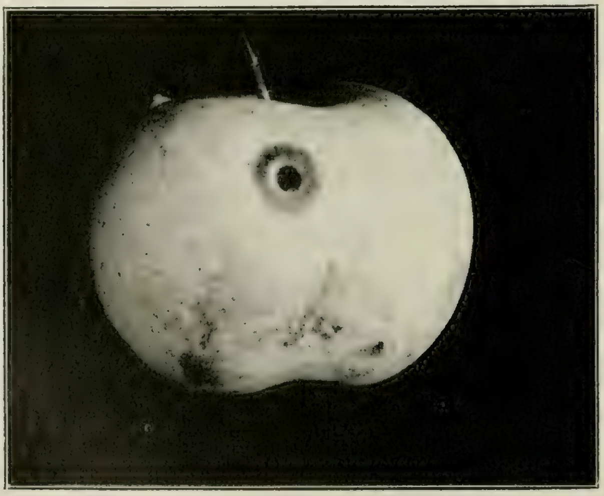


Fig. 6—Exit hole of codling moth

the dates computed are preferable to dates determined merely by guess work. The difficulty thus far has consisted in getting enough early "wormy" apples to fill the cages in time.

Much remains to be done in perfecting details and in determining the exact value of the influence of Lake Michigan in retarding the season in its immediate vicinity and in determining the influence of different soil conditions.

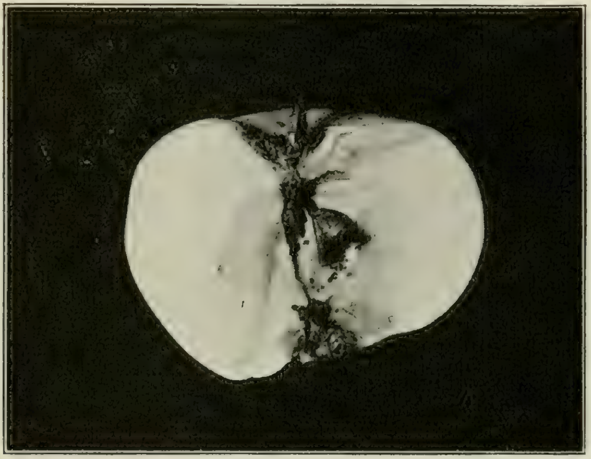


Fig. 7—Typical burrow of codling moth. Conspicuous about the core

GRAPE BLOSSOM MIDGE.

(*Contarinia johnsoni.*)

This insect which rather recently appeared in our state has heretofore

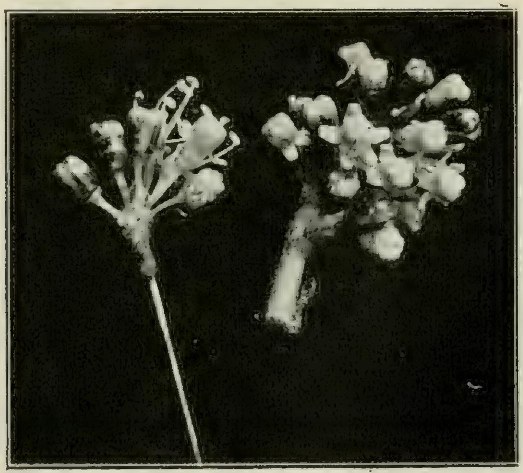


Fig. 8—Buds of grape. The dark colored and swollen buds contain the maggots of the grape-blossom midge

confined its attacks to a very restricted area. This year, however, it is spreading over the grape belt so that a few are to be found here and there in widely separated vineyards. The appearance of infested buds is shown in figure —.

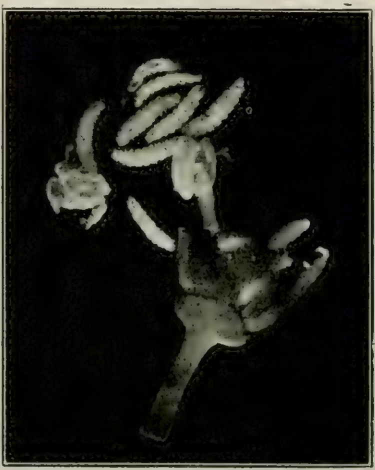


Fig. 9—Infested bud of grape teased apart to show maggots of grape-blossom midge

PEACH THRIPS.

The peach-thrips (*Thrips tritici*) is appearing and being recognized in other states. It continues to do an appreciable amount of injury to "Elbertas" almost every year in Michigan. Careful life-history studies and tests of control sprays are very desirable in the case of this

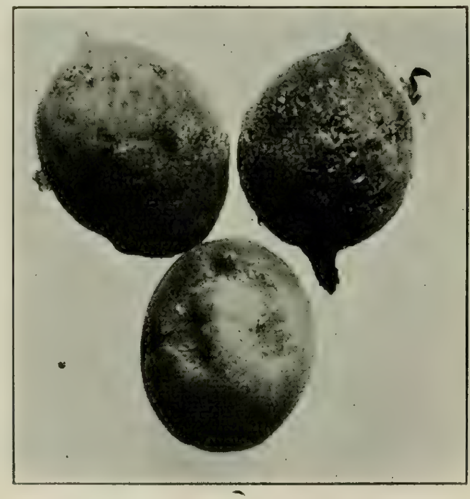


Fig. 10—Work of peach-thrips on Elberta peach

pest, especially in our state where the sale of fancy fruit in Chicago assumes such proportions. The peach-thrips does not destroy so much fruit but it puts what would otherwise be a fancy peach in the cull class and if any appreciable proportion is so affected, the money loss is severe.

THE SPRUCE CONE WORM.

(*Dioryctria reniculella.*)

A larva, whose adult was identified for us by Dr. August Busck of the National Museum, appeared during early June, 1923, on the young and tender leaders of Norway spruce. This slender larva which measured

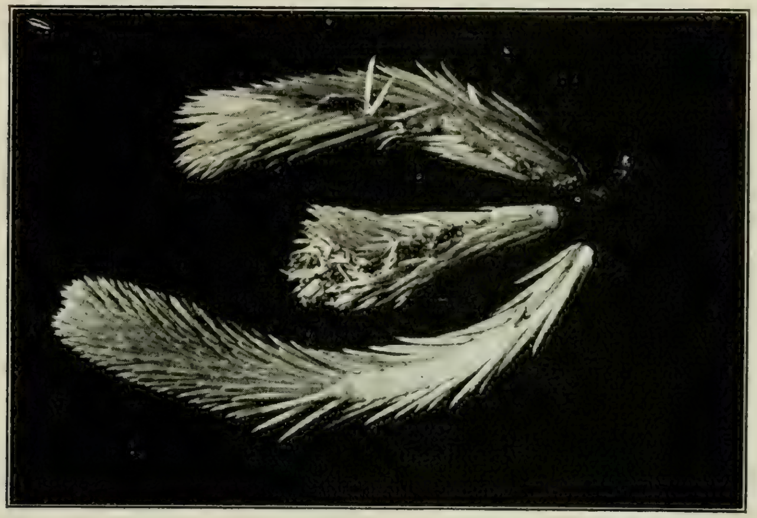


Fig. 11—Work of spruce cone-worm on leader of young Norway spruce

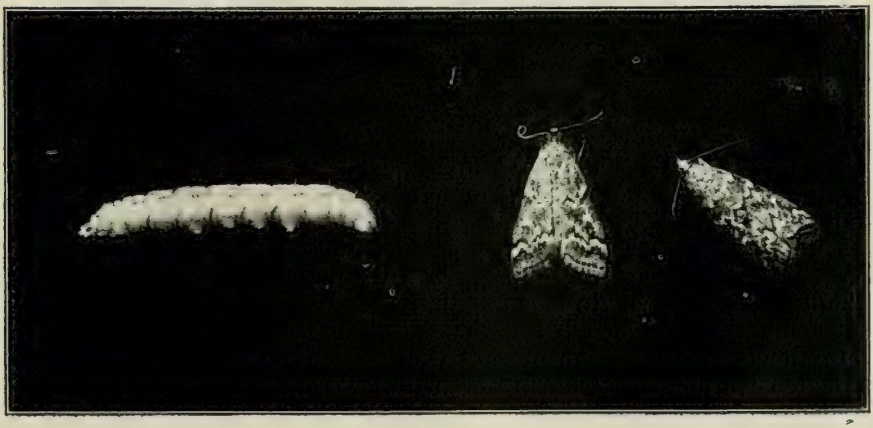


Fig. 12—The spruce cone-worm, larva and adults

about five-eighths of an inch long attacked sometimes the side of the soft leader and at other times it tunneled up through the center.

The species is recorded as webbing spruce cones together and of tunneling through the cones. Quite a large number of the young Norway spruces in the forestry nursery and others of small size which had recently been set, lost their leaders.

BIRCH LEAF SKELETONIZER.

(*Buculatrix canadensiella.*)

This insect seems to have come to stay for a while. Each year complaints come in from resorts in the vicinity of the Cheneaux Islands that the white birches are being defoliated, and these canoe birches play an important part in rendering our northern resorts attractive. We have recommended the application of a spray of arsenate of lead put on in the ordinary way.

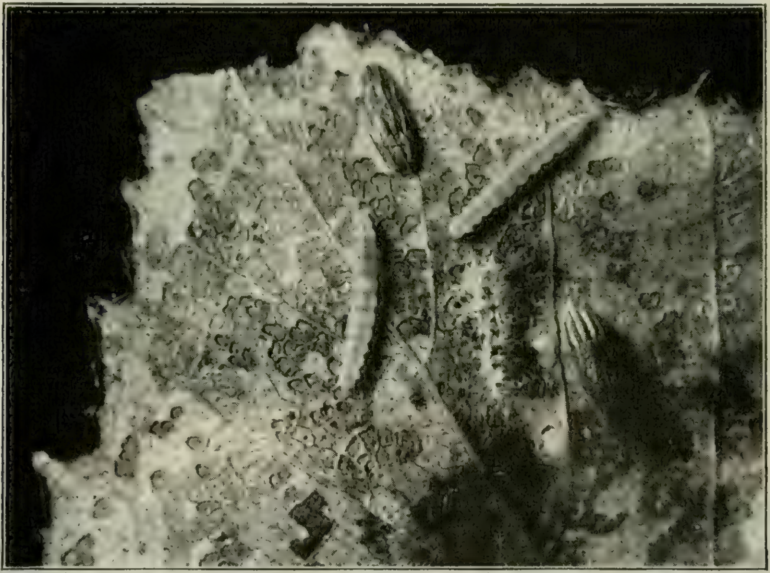


Fig. 13—Larva, cocoons and molting shelters of birch-leaf skeletonizer on leaf

Specimens received during late August and early September showed small, light-green larvae, less than one-fourth inch long, which skeletonize the leaves. There are also present very small white silken shelters used by the larvae during molting, and also ribbed copper-brown cocoons in which are the pupae. The winter is passed in the cocoon. The infestation seems to be spreading.

During the year of 1922-23 the European corn-borer has progressed very slowly. It is at the present writing confined to very small areas, no extensive new areas having been discovered.

The garden web-worm (*Loxostege similalis*) continues its depredations on alfalfa seedings. In controlling this pest the cultipacker has proven superior to the ordinary roller. It is usually adequate.

Several species of ants have made themselves conspicuous both in dwellings and in lawns.

The bumble flower-beetle appeared during the autumn and destroyed a certain amount of fruit. Inasmuch as this pest seems to have no adequate control its appearance is more to be dreaded than that of some more serious pests which may be kept in check.

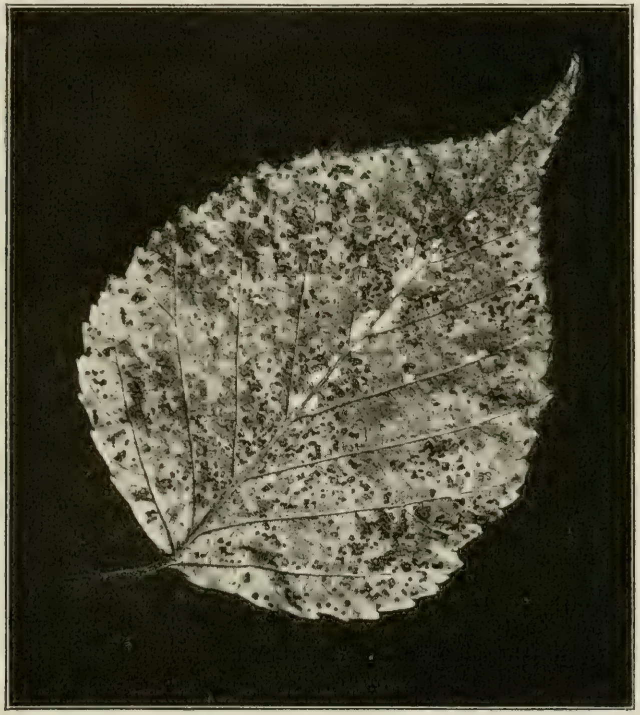


Fig. 14—Leaf of white-birch injured by the birch-leaf skeletonizer

Cucumber-beetles (*Diabotica vittata*) were unusually prominent and led to the publication of directions for their control, by dusting, in the Station Quarterly.

Cut-worms seem to be bad with us every year. One species as yet undetermined is strongly attracted to sweet clover, the county agent of Benzie county sending us fifty-two collected about the roots of a single sweet-clover plant.

Alabama argillacea appeared very late in the fall. We are beginning to expect it annually. No satisfactory control has yet appeared. Trap lanterns kill a few, and the covering of picked fruit seems to pay for itself.

ROSY APHIS IN 1923.

The rosy aphis of apple is present in numbers this year, the late season proving favorable to its development.

During the year the following articles were published in our Quarterly bulletins:

Vol. 5. August, 1922, No. 1, Cockroaches. E. I. McDaniel.
Vol. 5. February, 1923, No. 3, The Control of the Grapeberry moth. R. H. Pettit.
Vol. 5. May, 1923, No. 4, The Striped Cucumber-beetle. R. H. Pettit.
Vol. 5. May, 1923, No. 4, A Repellant for flat-headed borers. R. H. Pettit.

Special bulletin No. 76, by R. H. Kelty was revised and rewritten, being published in February, 1923. It deals with transferring bees.

Circular bulletin No. 51, on the Chinch-bug, by R. H. Pettit, was gotten out in August, 1922. Also Circular Bulletin 49 in July and Circular Bulletin 52 on the Grape-berry moth in December, 1922, by the same author.

The following four press bulletin by R. H. Kelty were printed during the year:

No. 65. October, 1922, How and When to Make Increase.
No. 66. October, 1922, Packing Cases for Outdoor Wintering.
No. 67. October, 1922, Queen Rearing for Home Use.
No. 68. October, 1922, The Tar-paper Packing case.

A circular on the cockscomb gall of elm is now ready for the printer.

During the fiscal year of 1922-23, some progress has been made in Adams Project 4e, being "an inquiry into the prevalence, extent of infestation, economic significance and methods of control of the pathogenic parasites of food animals." Dr. Chandler in whose charge this work lies reports the discovery of a very successful vermicide which promises a great deal in the matter of eradication of stomach-worms.

Under the headings of Hatch and State projects: Project 1, which deals with codling moth is discussed under that heading.

Project II: Studies in the control of insect pests in dwellings and stored foods in charge of Professor E. I. McDaniel, has progressed somewhat. Numbers of experiments have been made as opportunities presented themselves.

Project III: Studies in the control of insect pests of greenhouses, by Professor E. I. McDaniel, is somewhat further advanced, since the work of writing a bulletin has already been begun.

Project IV: Dealing with the control of the peach-borer, grape-leafhopper, grape-berry moth, and pear psylla, shows also some progress. A bulletin on the grape-berry moth has already been issued during the year and a number of tests in the use of paradichlorobenzene has been made for the control of the peach-borer.

Project V: Has been practically brought to a successful completion, a report of this project being recorded in this Annual Report.

Project VII: Was started during the summer of 1922. It deals with the records of business management of apiaries, being in charge of Mr.

Kelty of this department and Mr. Riddell of the Department of Farm Management, but during the reorganization of College affairs last Fall, Mr. Riddell was transferred to other work and thus far we have been unable to get any one else assigned to the project. Considerable preliminary work has been done in preparing blanks and distributing the same with directions to the beekeepers for filling in such blanks at intervals, but for the reasons givin nothing has been done for some time on this project.

A project on the pea aphis control was authorized at the instance of the Pea Canners of the State. This is an important matter since the pea aphis is the cause of enormous losses every few years. However, it has been impossible to attack this problem because no funds have been provided.

Respectfully submitted,
R. H. PETTIT,
Entomologist of Experiment Station.

REPORT OF THE SECTION OF FARM CROPS.

To the Director:

Sir:—I am glad to report development in our major lines of crops experimental work and the addition during the year of new projects, the fulfillment of which should give valuable results.

Co-operative arrangements have been made with the Bureau of Plant Industry of the United States Department of Agriculture for the carrying on of extensive sugar beet breeding and cultural projects. On April 1st the equipment of the Blissfield Station for sugar beet investigations was transferred to this station, and the U. S. D. A. North-central States' Sugar Beet Experimental Station was definitely placed at M. A. C. Mr. E. E. Down was transferred to half-time service on the Bureau of Plant Industry rolls, and is in charge of this phase of the work.

Mr. C. E. Cormany is devoting a large part of his time to cultural investigations with beets.

Breeding work with potatoes has reached a point where minor increases of improved strains will soon be available.

Herewith follows detailed reports from experiments in charge of the main projects:

REPORT OF RESEARCH ASSOCIATE F. A. SPRAGG,

In Charge of Plant Breeding Projects.

It seems that with the years our work is expanding, and yet the number of crops that we are dealing with is being reduced. The increased work comes as a result of dealing with a larger number of varieties, and a general expansion of the breeding work with the more important crops.

I feel that we are fortunate in being able to obtain the services of Mr. H. M. Brown to take the general line of investigations that Mr. Down lays down. Mr. B. B. Robinson is giving considerable assistance as a Graduate Assistant. In addition to this, certain projects would not be possible were it not for the fact that we were able to obtain the services of at least one advanced student during the summer. This year we had Mr. R. K. Rosa, who was with us last year to assist in the technical work. Also, I must acknowledge the efficient way in which Mr. Geo. Getman and his helpers take care of the preparation of the land, planting, cultivating, and harvesting the crops involved in these investigations. In the potato breeding work, Mr. Cormany continues with the immediate touch, giving me the advisory position in the breeding of this crop.

It seems a little difficult to give a brief outline of different lines of work in any other form than that of a table of plant breeding projects. The following statements bring out some points that characterize changes or developments since the last report:

Crop	Varietal Testing	Beds and Centgeners	Plant Rows	Milling and Baking	Increasing	Crossing	Segregation	Selfing	Winter Hardness	Disease Freeing	Disease Resistance	Chlonal Selection	Isolation
Alfalfa	√	√	√	......	......	......	√	......	√	......	√	......	......
Barley	√	√	......	......	......	......	......	......	......	......	......	......	......
Beans	√	√	√	......	√	......	√	......	......	......	√	......	......
Corn	......	√	......	......	√	√	√	√	......	......	......	......	√
Crimson Clover	......	√	......	......	......	......	√	......	......	......	√	......	.
Hemp	......	...	......	..	..	.	√	..	..	......	......	......	...
Hubam	......	......	......	......	......	......	√	√	√	......	......	......	√
Oats	√	√	......	...		.			..	......	......	...	......
Potatoes	...	...	......							√	......	√	√
Rye	√	√	√	......	......	......	√	√	√	......	......	......	√
Sugar Beets	√	√	√	......	......	......	√	√	......	......	√	.	√
Wheat	√	√	......	√	√	√	√	......	√	√	√	......	......

ALFALFA BREEDING.

Since the last report a new nursery including 11,400 individuals has been set out and it would appear that considerable improvement has been made since the last generation.

We now have not simply a Hardigan alfalfa, but a large number of strains of Hardigan that appear just as different from one another as the strains of alfalfa obtained from other sources differ from one another.

A large group of new strains come from Siberian sources. They may be expected to more winter-hardy. When we received the original lot of seed from which these lines come, it was planted in the 1916 nursery. Those plants showed great variability in erectness, color of blossoms, and most everything that would characterize differences in alfalfa. However, Siberian plants of the 1916 nursery were very poor seed producers. Some seed was saved from the row, however, and this was planted in the 1918 nursery where we found a few plants with a reasonable good seed production. These strains were again selected for the 1920 nursery where they showed great desirability from the standpoint of commercial alfalfa. In the 1922 nursery most of these strains are quite erect, have unusually low crowns, and seem to be high producers of hay.

The segregation of the color of the flower of the Siberian lot of alfalfa enticed Mr. B. B. Robinson to attempt a study of the inheritance in alfalfa as a master's thesis, and for that purpose he set out approximately ten thousand individual plants in the spring of 1923.

At the present writing it would seem that there are a number of strains of alfalfa in the nursery that would be even more desirable commercial varieties than the Hardigan now in the hands of farmers. These are strains coming from Hardigan after passing through three more generations of individual plants. As soon as the problem of increasing alfalfa can be worked out among farmers these new strains should be increased and distributed.

BARLEY BREEDING.

The barley investigation at the present time has been greatly reduced. It is represented by a series of small lots that are being increased to plant a varietal series as soon as the three years of oat-testing is complete, and the land is available. Most of the strains in this barley series come from a cross between Mich-2-Row, and Michigan Black Barbless barleys. This cross was made in 1916, and the strains that are being saved are white, smooth awned types. The hope is that a good yielder may be found from among them.

BEAN BREEDING.

About six acres are devoted to the bean varietal series. This new series was first planted in the season of 1921, but because of the adverse conditions at harvest, we feel the results of that season are not reliable. Thus we will consider the bean series in the second year with one more year to go if we are to obtain a three-year average.

These are all white pea beans coming from selections that were made during the time that the bean varietal series of 1917 to 1920 was being run. In addition to this series we have been continuing our selection work from other sources, and from crosses from the various varieties of field beans.

A year ago we were asked to take on garden beans because that line of breeding was not being carried at the Michigan Agricultural College. This work is being expanded in the present year with the co-operation of Mr. George Starr who has recently come to the institution to take up the breeding of garden crops. When the testing of the present varietal series is complete we hope to have a large number of new strains coming from promising individual plants, that are sufficiently increased to plant individual plats in a new varietal series. This new varietal series no doubt will be partly field sorts and partly garden varieties.

CORN BREEDING.

Corn breeding work has expanded considerably since the last writing. In 1921 a large number of selfed ears were obtained which were tested in boxes to eliminate such ears as showed undesirable seedling characters. The ears that stood the box test were further tested in an ear-row series in the summer of 1922. A strain of Golden Glow, being used as a check, was planted in each third row of that series. Perhaps half of the corn in the ear-row test came from the Duncan variety, and we were very greatly surprised to discover the number of types and the great range of characteristics to be found in one variety when the individual strains are represented by selfed ears.

Many of these strains were unusually early and small. A few were especially late and large. A few of the rows had unusually uniform ears when harvested, but a great many of them had undesirable types.

During the season anyone who examined the series critically could not help being struck with the uniformity of the plants in the row as contrasted with the lack of uniformity among the plants of a commercial variety. All these rows were represented by remants which were saved for future planting.

The isolated corn plats of this year are mostly the inter-rowing of desirable remnants in order to obtain a complete cross to be used in future work. For instance, a cross would be made between remants whose rows were similar in point of earliness in the ear-row test, showed exceptionally good characters, and were high in general production.

There is no ear-row test in 1923, but the breeding plat is planted almost entirely to corn coming from inter-crossed remnants from previous years which are expected to segregate this year. As many self-fertilized ears will be obtained from this block as our time and ability will permit, and from this a much larger ear-row test will be planted in 1924 from ears that stand the test in boxes during the winter.

CRIMSON CLOVER BREEDING.

In the last report two lines of Crimson clover work were mentioned, the one being planted in the spring, and the other in the fall. The fall planted lot appears to be a failure as most of the stock was completely frozen out in the winter of 1921-1922. The spring planted strain was obtained from Antrim County and drilled in rows about May 1st, 1921. These rows proved to have such a mass of mosaic that it seemed no seed could be produced. However, some seed was saved, enough to plant a bed in the spring of 1922. These plants were sorted to eliminate those that had already developed mosaic when they were about six weeks old. The healthy plants were planted on the same land that had produced such a mass of mosaic clover the year before. The land had been plowed and fitted, but would be expected to contain a large amount of disease. This was done in the hopes that some disease-resistant individual might be found, and a few were found that did not develop mosaic up to the time of maturity.

Seed was saved from these healthy plants, and their progenies have been set out in a new nursery of 1923. They are again planted on the land that has grown diseased plants two years. Seedlings of this year did not seem to have any mosaic on them at the time they were planted. The indications are that progress is being made in the breeding of a disease-resistant Crimson clover that may be produced as a summer annual under Michigan conditions. It would appear that such seed may be planted in the fall as an orchard cover crop which may make a vigorous growth in the fall, and be winter-killed. I am told that this is the kind of cover crop that is desired by orchardists.

HEMP BREEDING.

The hemp work has proceeded to a point where the station now possesses a strain that is worthy of increase as soon as a hemp industry needs such an increase. It is vigorous and ripens seed under Michigan conditions.

HUBAM BREEDING.

Hubam as it is generally known is an annual white sweet clover. The race that is being carried on survives the winter.

There were five acres of Hubam on the college farm in 1920. The following spring it was discovered that about one hundred plants on an acre were still alive. Some of these plants were transplanted in a group entirely away from the general field. The seed from these individuals was used to set out a Hubam nursery in the summer of 1922. This race segregated extensively into types that blossomed the first year and those that did not.

We are continuing with individuals that produced flowers in the first season, and survived the following winter, with the thought that it may be possible to produce a perennial sweet clover. It is well-known that the ordinary biennial type dies when once it has produced its seed crop. If this work can find a strain that can produce seed, and survive, it is clearly of a different type.

There is also another line of sweet clover investigation that may be mentioned here. It is a low bush type that sends up a large number of fine stems in the place of a few large but taller ones. This low bush type has been observed in both the Hubam and the biennial types. A strain of low bush beinnial has been isolated, and if it can be kept from being crossed upon, should be productive of a much better quality hay than is possible by the old type.

OAT BREEDING.

The work with oats at the present time is almost entirely confined to extensive varietal testing. Most of the varieties are strains that have come from individual plant selections in former years. Certain promising commercial sorts, together with certain new strains that have been produced by other experiment stations are also included in the varietal series.

POTATO BREEDING.

Of the thirty-one hundred tuber-units planted in the spring of 1921 only eight hundred and fifty-four were saved in the fall because these were superior in yielding quality. A tuber was taken out of each of these for testing in the greenhouse. A bud from each such tuber was planted to determine whether the individual tuber contained Mosaic or other physiological diseases. If a bud developed any of these diseases, the potato and the tuber-unit, from which it came, were discarded. This work reduced the number of units to five hundred and sixty-five. The healthy tubers were planted in new tuber-unit series in 1922.

These were again tested in the greenhouse during last winter by taking a bud out of a potato from each tuber-unit. If the bud developed disease, the lot that the bud represented was discarded. This reduced the number of units to one hundred and sixty-three. The healthy tubers were planted in tuber-unit lots in 1923.

It seems very difficult to get away from Mosaic, and other physiological diseases. The hope is that a strain may be found entirely free from these diseases that will also be a high producer. The purpose is to run the disease-free lots in varital series and increase the highest yielder for the general trade.

A row series was run in 1922 representing the five hundred and sixty-five lots from which the healthy tubers came. This row-series was checked with a tuber-line coming from the Upper Peninsula Experiment Station.

During the last winter a large number of tubers from the check strain was also tested, and we were surprised to find that a large portion of these also developed disease under greenhouse test. The sixty-one healthy tubers from the check strain are also planted in the 1923 tuber-unit series.

There is also a row series planted in 1923 from the one hundred and sixty-five units from which a healthy tuber was obtained as indicated by greenhouse test. This series, however, does not contain a check because the check that we were using contains too much disease and we have no other strain that is sufficiently increased to be used as a check. These rows may be considered an increase, and if they prove to be healthy a varietal series can be set up, as soon as a healthy strain can be increased sufficiently to be used as a check.

RYE BREEDING.

The table of projects shows seven different interests in rye breeding. These have several cross relations.

In the first place we have a large number of strains coming from selfed heads that are being isolated in order to obtain enough seed to plant a row series in the fall.

This row series will be planted from a portion of each lot of seed. The remnants will be saved for future planting. This process has already been run through once and the remnants of the most desirable lines are now under inter-cross. The thought is that selfing may reduce the vigor somewhat, and that inter-crossing of the remnants will return the vigor. Selfing is necessary if definite characters are to be fixed and certain others eliminated.

In the fall of 1921 a large number of ryes were obtained from various experiment stations over the country. Our circular letter aimed to find all of the ryes that are being recommended by experiment stations. These ryes were included in a varietal series which also included a number of strains of Rosen. The series was repeated this year and will be repeated the third year in order that we may find the better yielding ryes for breeding purposes and that we may become intelligent regarding the relative values of the various pedigreed varieties under Michigan conditions.

About five thousand individuals in each of the rye varietal series of the past two years have been covered with little parafined envelopes in order that the kernels produced on the heads would be self-fertilized. The selfed heads of last year that contained reasonable numbers of kernels of desirable quality produced the lots of seed that were isolated this year for increase. The isolation was accomplished by planting the lots two rods apart in the alleys of the wheat series and enclosing in cheese-cloth.

SUGAR BEET BREEDING.

The sugar beet breeding work had its beginning in 1919, when Mr. Hugh Smith made a large number of selections from a few commercial sorts. He used these in the following year in connection with his thesis on methods of breeding sugar beets.

When Mr. Down returned from the war he brought with him a strain of beets from Germany, and undertook the collection of all the promising commercial lots of sugar beets that could be found in the trade of this country. In 1921 Mr. Down planted a varietal series, and has repeated the series in each of the following two years.

In 1922 an attempt was made to self-fertilize individual selections in isolation. Those that had been selected at the Michigan Agricultural College were planted in farmers' gardens not far from the college, but because of poor storage conditions these beets did not do well.

Another lot of isolations was obtained from the St. Louis Sugar Company. These were planted by Mr. Down in Gratiot county, and from that source he has obtained quite a number of lots of seed from individual beets. These progenies are included in the 1923 series. In addition to this, the United States Department discontinued their plant breeding work at Blissfield this spring, asking us to continue the work with the stock that they had at hand in connection with that station. This has so expanded the sugar beet breeding work that Mr. Down will now devote his entire time to that crop.

WHEAT BREEDING.

The present wheat varietal series contains a large number of selections coming from the crossing work of previous years, notably 1912, 1916, and 1919. These are stranis that have been fixed in the centgener plats and are now under a competitive yield test. Six of these are also being increased for distribution. In addition to this the centgener series of this year contains an extension of the selection work from crosses of more recent date, and also from commercial sources. A new series of crosses in wheat was made in the spring of 1923.

REPORT OF RESEARCH ASSOCIATE C. R. MEGEE.

IN CHARGE OF FORAGE CROP INVESTIGATIONS.

A study of the value of clover seed from the various producing centers for Michigan conditions:

Southern European strains were found to be inferior to Michigan Red Clover. Plants from Italian seed were much less winter hardy and much more susceptible to anthracnose than plants from Michigan seed. The French strain was not injured to as great an extent as the Italian. However, it showed considerable winter killing and anthracnose, and was inferior to the Michigan strain. A number of strains from Northern

Europe, including Tystofte from Denmark, Broad red and Montgomery red from Wales, and a Hamburg strain, were compared and none found to be superior to Michigan seed.

A comparison of the different strains of sweet clover:

In this test the biennial yellow yielded somewhat less, approximately two-thirds, as much as the biennial white sweet clover.

It was from seven to ten days later than the biennial white and had a smaller stem and finer leaf. The Early Dwarf also known as the Grundy County Illinois White Sweet Clover was finer stemmed than the common biennial white.

Hubam or annual white sweet clover was found to give about the same yield as the biennial white when sown and harvested the same season. The dry matter per acre produced by the root system of the biennial white was materially greater than that produced by the Hubam.

For pasture and green manuring the biennial white strain is to be recommended, while for hay production the Early Dwarf due to its fine stem deserves further consideration.

Soybean variety test:

A number of soybean varieties have been tested for both forage and seed production. The Manchu gave the highest yield of both seed and forage. Other varieties worthy of mention are the Ito San and Black Eyebrow.

The comparative adaptability of different species of legumes to muck, sand and sandy loam:

The different species of Trifolium such as Pratense, Subterranean, Dubium, Panonicum, Fragiferum, Hybridum and Repense as well as different species of Lespedeza, Lotus, Lupinus, Melilotus, Medicago, Poterium and Anthylis are being studied. Project started spring of 1923.

Mammoth clover:

A study of the plant characteristics of a hundred lots of Mammoth Red clover secured from various sections of the state.

White clover studies:

A study of the plant characteristics of a number of white clover strains including English wild white.

A study of the value of alfalfa seed from the various production centers:

The variegated strains, especially Hardigan and Grimm were found to be superior to any of the common strains. The northern grown common strains, however, were far superior to the southern grown common, such as Arizona common and Hairy Peruvian.

REPORT ON CORN PROJECTS.

BY J. R. DUNCAN, CORN SPECIALIST.

Ear-row plat M. A. C. Duncan, 51 ears.
Ear-row plat M. A. C. Yellow Dent, 51 ears.
Ear-row plat, ear character study, 63 ears.
Variety plat, 24 varieties.
Rate of planting plat, 12 spacings.
Merger plat (6 ears), M. A. C. Duncan
Merger plat (6 ears) M. A. C. Yellow Dent.
Merger plat (8 ears) Selfed strains Duncan.
Merger plat (7 ears) Hulless Popcorn.
Increase plat (one acre) Frost Resistant Duncan.
Increase field (ten acres) M. A. C. Duncan.
Increase field (ten acres) M. A. C. Yellow Dent.

Continuing the co-operative work with the W. R. Roach Canning Company on the improvement of sweet corn varieties, the seed from the merger plats of 1922 was carefully inspected for planting an eight to ten-acre increase field this year of each of the following five varieties:

Early Bantam.
Crosby.
Hickox.
Shaker.
Evergreen.

REPORT OF CROP EXPERIMENTS.

D. F. RAINEY, ASSISTANT IN EXPERIMENTAL WORK.

In conducting co-operative varietal demonstrations, we are following Experiment Station practices right on the farm, thus giving the farmers of a community accurate comparative data secured locally, on the basis of which they can make their choice of the variety to raise.

Because we usually plant but one demonstration of a kind in any one county, and an attempt is made to distribute the work widely over the state, there are necessarily few demonstrations of each kind planted; and further, but one man is doing this work.

In furtherance of our plans to show by varietal demonstration plots the superior yielding ability of the pedigreed grains over most local strains, the following have been planted during the past year:

3 wheat demonstration plots.
2 oat demonstration plots.
5 field bean demonstration plots.

To demonstrate the relative hardiness and consequent yielding ability of the varieties of alfalfa there have been five varietal plats planted and arrangements made for planting six more later this summer. Most plats contain six to nine varieties, the seed coming from many states and two or three countries.

Nine soybean varietal plats have been sown to determine adaptability of different varieties and to demonstrate the value of soybeans as a hay crop. They are proving a popular emergency crop escecially on the lighter soils.

To enable us to get more information regarding adaptability, growth, use, etc., of Hubam clover, we have distributed approximately 275 pounds in fifteen-pound lots, each farmer also getting fifteen pounds of White Blossom Biennial Sweet Clover, so that they might report on the comparative growth of each variety.

Arrangements have been made for each of five farmers to seed a four-acre plot, either marsh, new land, cut-over land or very light sandy land with a seeding mixture of June clover, Red Top, Sweet Clover, Alfalfa, Alsike Clover, Brome grass, Kentucky blue grass, White clover, Meadow Fescue and Orchard grass, which we furnished.

We hope to find out what plants will grow and make pasture in some parts of the state, on what is at present waste land of little or no agricultural value.

The above report is respectfully submitted,

J. F. COX,
Professor of Farm Crops.

REPORT OF THE SECTION OF FARM MECHANICS.

To the Director:

Sir:—Following is a report of the investigational and experimental work of the Farm Mechanics section for the year 1922-1923:

The work of this section is reported under three major groups to-wit, Farm Buildings and Conveniences, Farm and Power Machinery, and Drainage and Land Clearing.

FARM BUILDINGS AND CONVENIENCES.

The Experiment Station work in farm buildings for the past year has been given over quite largely to a study of storage houses. Both potato and apple houses have been observed and the study has included houses of a size suitable for the individual farmer as well as larger houses suitable for the use of co-operation associations. The work has been limited to locating and studying houses in various parts of the

State. Ventilation is the most important factor in successful storage with the exception of temperature control. Special emphasis has been laid on the methods which will prove satisfactory.

The article, "The Ventilation of Potato Warehouses," in the August quarterly 1922 is based on investigations of a number of houses owned and operated by co-operative associations.

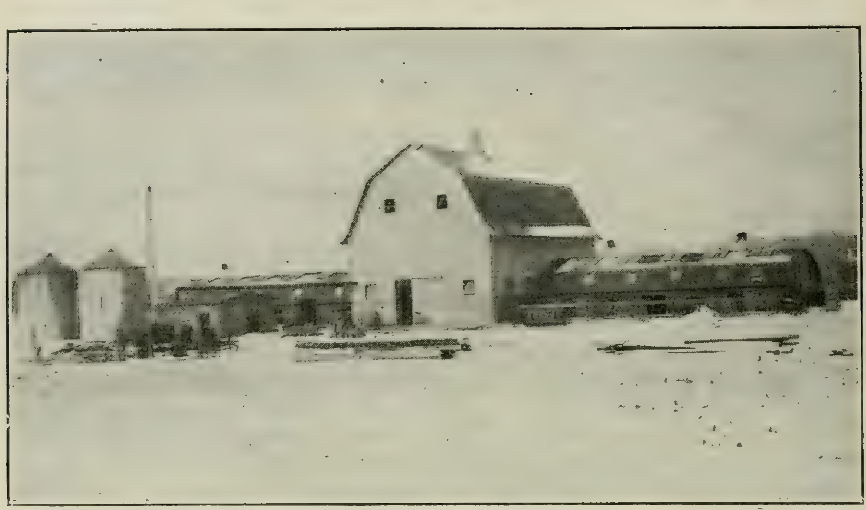


Fig. 1.—The New Piggery.

Many requests are being received for aid in planning ventilation for

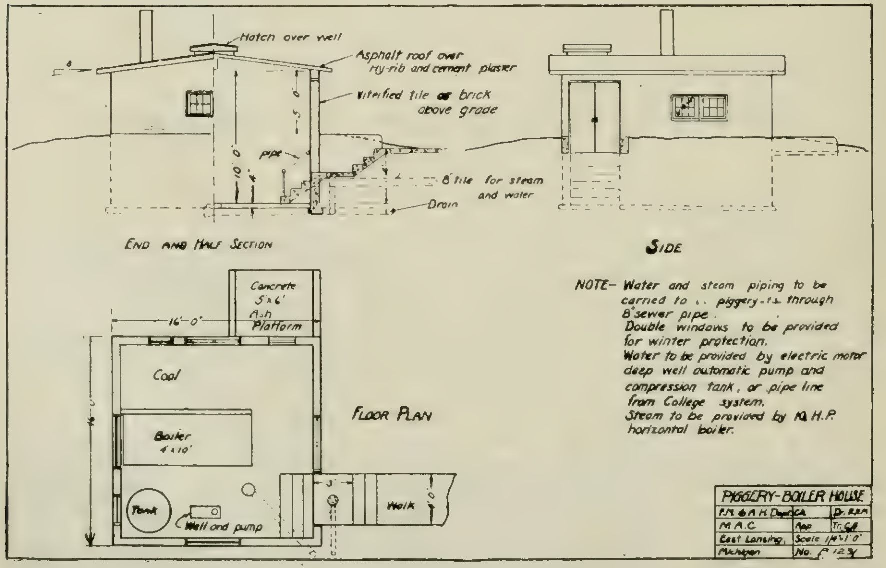


Fig. 2.—Boiler house for new Piggery.

storage houses. As each case is a special one considerable time is required to handle these inquiries. This seems warranted in view of the fact that we have the co-operation of the individual in observing the operation of the system and noting the results.

Three houses in particular, two private and one owned by a co-operative association have recently been built embodying principles brought out by our investigations. These houses will be under our observation to determine with what success they operate.

A new root storage house is about to be completed on the College Farm. This house was designed so that various systems of ventilation may be operated and very carefully studied.

A piggery designed by this department has been built for the college herd on a site south of the Red Cedar river. This plant consists of a two-story structure with a one-story wing to the East and one to the West with a separate building for the heating plant. The two-story portion is 30 ft. x 52 ft. and provides storage for grain and roughage, cooking vats, horse stalls, scales, and a room for an attendant. The east wing 26 ft. x 66 ft. 6 inches provides twelve pens for experimental purposes. The west wing 26 ft. x 48 ft. 6 inches contains twelve farrowing pens. The center building is of frame construction on a 4 ft. 6 in. solid concrete wall. The sidewalls of the wings are solid concrete, the roof being frame with asphalt shingles and ceiled under the rafters with 6 in. flooring material. The troughs and floor are of concrete with cork brick in the nestings beds. The pen partitions are of iron pipe. Each pen is provided with an outside run which is cemented.

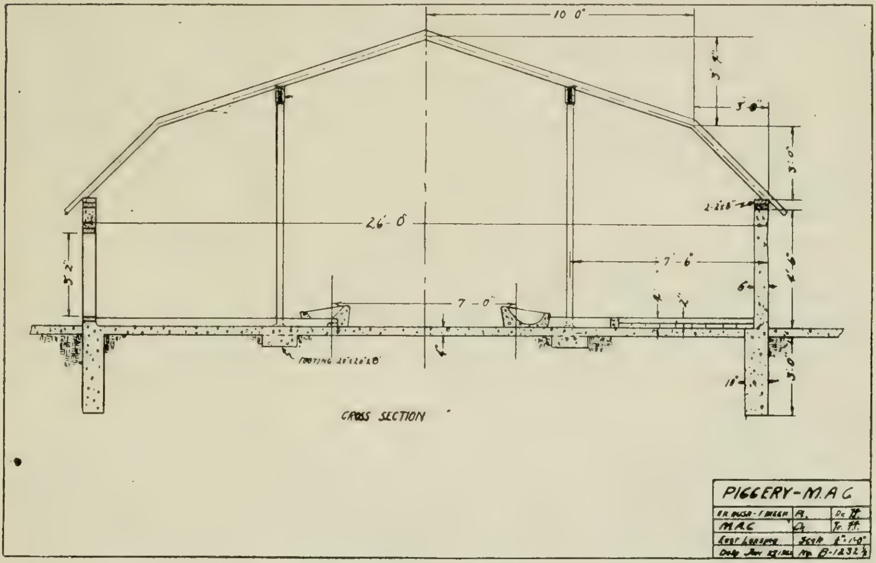


Fig. 3.—Cross section showing construction of each wing.

An over-head track equipped with a swill carrier and a litter carrier runs the entire length of the center alley, and out the south door.

The farrowing pens are provided with heat coils to protect early litters. Steam for heat and feed cooking is provided by a horizontal boiler taken from a discarded traction engine. The boiler, the well, and water system are located in a separate cement block building about forty feet from the main building.

The correspondence pertaining to farm conveniences and farm buildings is increasing greatly. Many of the inquiries to be satisfactorily answered require special plans and sketches; especially is this true of problems of remodeling, ventilation, and septic tank installations.

DRAINAGE AND LAND CLEARING.

In drainage little work of an investigational nature has been possible in the last year. The Extension Specialist who hoped to carry out some experiments in determining water levels in the soil has not had time to carry out this work. A few test wells for vertical drainage were made by the Land Clearing Specialist while in the southern part of the State last year. This work should be further tried to determine the percentage of cases in which success may be expected by this method for draining the large number of post holes prevalent in Michigan farms. Some experimental work should also be started in the Upper Peninsula as the value of drainage to that section of the state should be determined.

The work of testing tile has been continued, although no special effort has been made to extend the application.

Some study has been made by the Land Clearing Specialist by collecting information on the utilization of native timber and the use of easily made devices by the settler on the new farm. This summer work is also being done by methods of plowing new ground at the Chatham Station. Horses and tractors and different types of plows are being tried.

Last April we began work on the development of low cost equipment for handling marl. Marl is being handled in a commercial way to some extent by contractors who use high cost equipment and the limited use of marl where its value is not fully understood, has not permitted rapid development of this method of handling. It is felt that the smaller outfit might be of great value in introducing the use of marl and in the educational and demonstrational value which simple and inexpensive equipment would have.

Experiments have been made principally with the dragline and bucket plans of handling. Special attention has been directed to developing a small bucket which will handle the material satisfactorily. It is felt also that practical results can be obtained before the close of the season.

Other minor co-operative and experimental work is being carried out. Tests were conducted on a special lattice type tractor wheel which gave excellent results on loose and sandy soil. This would be of value for many Michigan farms. The use and test of the simple Lime Spreader have been continued.

Yours very truly,
H. H. MUSSELMAN,
Professor of Farm Mechanics.

REPORT OF THE SECTION OF FORESTRY.

To the Director:

Sir:—I herewith submit a brief report of the work of the Section of Forestry for the year ending June 30, 1923:

The study of second growth hardwoods on cut-over land in the northern part of the State was completed. The report shows the amount of timber which may be expected in second growth stands at various ages and indicates methods of improving such stands. It is based on a large amount of data collected at various places in the northern part of the State during the last few years and makes, I think, a valuable contribution to our knowledge of the second growth hardwood forests in Michigan.

The study of the rate of growth and returns that may be expected from thinnings in woodlots in the southern part of the State was also completed during the year. It is based upon a large number of measurements and indicates better methods of management for such woodlots as well as showing what per cent of timber should be cut in order to improve the composition and increase the rate of growth.

A study of nut tree plantations including the range of nut trees in Michigan, crop and market conditions and methods of improveing the varieties of nuts produced was carried on and completed by Professor J. C. DeCamp during the year. It is felt that the results of this work will be of much value in answering inquiries from people interested in such plantations.

The study of sap flow in the College sugar bush was continued and records kept of costs per gallon of syrup made. These results are published from time to time in the Experiment Station Quarterly.

The experimental work on the basket willow plantation at Spring Lake, which has been carried on for six years, was discontinued. The plantation had shown a profit for the last three years and the results obtained indicate the costs and receipts that may be expected from such plantations.

The periodic measurements which are being made on various forest plantations throughout Michigan were continued during the year. The work will show the actual rate of growth and the per cent of decrease in number of trees per acre at various ages.

A series of experiments were carried on by Mr. Herbert in killing trees by the use of poisons so as to prevent their sending up shoots from the roots or stumps. These experiments have been partially successful but the work should be continued another season in order to get positive results. Mr. Herbert also did considerable work in the hybridization of certain forest trees and in a study of the effect of pruning on height and diameter growth. These latter studies must necessarily be continued for some years before results are obtained.

Respectfully submitted,
A. K. CHITTENDEN,
Forester.

REPORT OF THE SECTION OF HORTICULTURE.

To the Director:

Sir:—I beg to submit the following report on the investigational activities of the Department of Horticulture for the year ending June 30, 1923:

In a general way it may be stated that work has been prosecuted and definite progress made on each and every one of the projects on which the Department was engaged at the beginning of the year. No one project has been carried through to completion, though work on certain aspects of several projects is nearing completion and probably will be finished within the coming year.

Special Bulletin 118 on Pruning Fruit Trees, by R. E. Marshall, has been issued during the year and brings together much general information on the subject as well as reporting on certain aspects of our pruning project. Judging by the demand for it, it is meeting a real need in the State.

Special Bulletin 121 on Grape Production in Michigan, by N. L. Partridge, is a popular treatise on grape growing and is meeting a widespread demand for information on that subject. It serves as a progress report on certain aspects of our grape investigations.

Bulletin 262 on Suggestions on Planting Orchards has been revised by R. E. Marshall and reprinted.

Enlargement of the staff of the Department has made possible a much greater amount of work on certain of the Station's projects, particularly those dealing with the use of fertilizers in the orchard and on small fruits, orchard spraying, testing different strains of vegetable varieties, and vegetable seed improvement.

New Station projects approved and started during the year include the following: (1) Cherry orchard nutrition studies; (2) Studies in orchard economics; (3) Baldwin fruit spot investigations; (4) Studies in the nutrition of cabbage.

Work at both the Graham and South Haven experimental sub-stations has followed the established lines for those stations—cultural plot investigations at the Graham station and variety trials and breeding work at the South Haven station. The cultural plots at the Graham Station are proving of great interest to many visitors and are beginning to yield results of real value. At the South Haven Station much work has been done with peach varieties and a manuscript prepared on "An Analysis of the Peach Variety Question in Michigan." It is expected that this will be published at an early date. The work at the South Haven Station this season has branched out to include a comprehensive study of the relation of different methods of pruning to the yields and bearing habits of the black and red raspberries. Mention should also be made of the fact that there is being assembled at the South Haven Station an extensive collection of yellow-fleshed cling peaches promising for the canning trade and a collection of the improved and named varieties of the huckleberry; at the Graham Station a similar collection is being assembled of the improved hardy nut varieties.

At present, adequate facilities are lacking for a laboratory study of samples of fruit, fruit spurs, leaves, roots and other tissues from cultural, fertilizer and other experimental plots. However, it is expected that such facilities will be provided in the research laboratories of the new Horticultural Building.

An effort has been made to meet the increasing demand on the part of growers' organizations and other horticultural interests for lectures, demonstrations and various other types of service. This is a type of extension work, but it has seemed desirable for some of the resident instruction and experiment station staff to devote a small portion of their time to it.

Much of the investigational work of the department is conducted away from East Lansing, an effort being made so to locate it as to reach the largest number of growers and work under conditions typical of the particular industry or problem.

Respectfully submitted,
V. R. GARDNER,
Horticulturist.

REPORT OF THE SECTION OF POULTRY HUSBANDRY.

To the Director:

Sir:—I herewith submit a brief report of the work of the Section of Poultry for the year ending June 30, 1923:

Complete reports of the experimental poultry work are not available at this time owing to the fact that the poultry year is operative from November 1st, to October 31st.

The First Michigan International Egg Laying Contest, which is now in operation will be concluded the last day of October. Complete trapnest records on one thousand hens in competition and an additional one hundred in reserve, are being recorded. The entries include thirteen popular commercial varieties of poultry entered by prominent breeders in fifteen different states.

The following information of real economic importance is being accumulated:

(1) Complete records on feed consumption including grain, dry and wet mash, milk, grit, shell, and charcoal, are made on all pens.

(2) The time and duration of the moult and its relation to yearly records.

(3) Weight of eggs by breeds at different seasons of the year.

(4) Graph showing curves representing production, by breeds, and the influence of weather on seasonal egg records.

(5) Symptoms and autopsies by H. J. Stafseth of the Division of Bacteriology of all mortalities occurring during the contest year. Meth-

ods of controlling epidemics of Chicken Pox and Cholera, have been tried with data and observations recorded.

(6) All birds are scored according to the "Standard of Perfection," which will furnish information on relationship of standard type to egg production.

(7) All birds are handled for comparison of the various methods of culling now in practice.

(8) Broodiness in breeds and the relative time lost each year due to this factor, are recorded.

(9) Date on operation of contest houses as a feasibility of such a house for pedigree pens in a commercial breeding plant.

(10) Breed egg averages, weight, net returns over food costs, and market value of fowl at completion of first laying year.

The Laying contests will in all probability extend over a period of years. This will make possible valuable information on comparative methods of management, thereby obtaining data on both breeding and environment, in relation to economic production.

Respectfully submitted,
E. C. FOREMAN,
Poultryman.

REPORT OF THE SECTION OF SOILS.

To the Director:

Sir:—Experiment Station activities of the soils section may be conveniently grouped into: (a) field or soil surveying, moisture relationships, aeration, root development of the crops under different soil conditions and various phases of fertilization; (b) laboratory or the chemical and physical properties of various soil profiles of the State, and the effect of soil fertility upon the quality of several crops.

It is gratifying to report that the soil survey has progressed very satisfactorily, J. O. Veatch deserving much credit for its success. Detailed studies were made of the soils in Berrien, VanBuren, Kalamazoo, Ottawa and Manistee counties. Lime requirement maps and reports on seven counties were published and distributed. In addition the greater part of a report on the sandy soils of the lower peninsula was completed. We have found that the agricultural value of the sandy soils of the northern part of the state is dependent in a great measure upon the presence of a brown and somewhat consolidated horizon which lies from a few to several inches below the surface. Where this is well developed and its thickness at or near the maximum we find the best soils and on these numerous crops and fruit trees adapted to the climate will grow successfully. It is at once apparent that this is one of the most important contributions of soil survey proper.

It is obvious that the moisture relationships of soils are of great and fundamental importance. The earlier moisture studies as a whole could be criticised on the basis of the method of collecting the samples of soil. In general they have been taken arbitrarily or to a given depth. Since the inauguration of the soil profile method of classification and method of attacking soil problems, the work has been placed on a logical and scientific basis, and, as a result of this we have found tremendous differences to exist which otherwise would have been masked to a greater or less extent. Certain sandy soils of the northern part of the state are less drouthy than others because of the presence of the brown layer spoken of above. It may be cited for example that in case of the Mancelona type the gray sandy layer below the leaf mold holds about three and one-half or four per cent capillary water whereas the brown layer retains from eight to twelve per cent and the sandy layer below about four. Our future plans call for extensive moisture studies of the main soil types of the state.

Information on the aeration of soils is unsatisfactory and meagre. This question is being studied by Dr. Bouyoucos under Adams project 2a. The indications are that the influence of barometric pressure is great and is felt to a depth of several feet it is probable that the curves obtained from barographs placed in the soil are similar to those located above the surface of the ground. This seems plausible since where the roots of various plants were covered with cement to a depth of about two feet they grew as vigorously as those nearby not so treated.

Investigations of the soil conditions that affect the root development of crops have been continued and expanded. It has been found that the nature and extent of root development of alfalfa is governed very largely by the nature of the soil profile. In case of some soil types they penetrate readily and deeply while in cases of others such as the Fox sandy loam they find difficulty in penetrating and as a result are twisted to a greater extent than those grown in others. It has also been found that old plants removed from the soil and placed in sterile sand may produce several crops from the plant food reserve in the root systems. Efforts are being made to determine whether the material in the lower layers of soil are used by the crops and to what extent. This we take it is of fundamental importance.

The soil fertility work has been broadened and extended since the employment of Mr. O. B. Price. The State has been divided into two parts, East and West respectively, Mr. Price having charge of the work in the former and Mr. Grantham of that in the latter.

According to Price, "the soil fertility work in the southeastern section has been increased from eight to fifty-seven projects since the Fall of 1922. These projects include a comparison of the rate, method and time of application of fertilizing materials and limestone on wheat, rye, corn, oats, beans, sugar beets, potatoes, alfalfa, sweet clover, Hubam and timothy and clover.

In the Fall of 1922 twenty-seven lime projects were located in seven of the southeastern counties. The object being to determine the rate at which limestone screenings should be applied, applications were made at rates from one to six tons. Fifteen of these projects were sown to wheat and seeded this spring to alfalfa or clover. The projects are to run through a rotation of four to five years. This spring applications of pulverized limestone and hydrated lime were used with the screenings, as a comparison of effectiveness of different kinds of liming materials. The effectiveness is shown in the accompanying table. Comparison of standard Michigan fertilizers was made on these wheat projects. The applications of fertilizers are to continue through the next four years.

RESULTS OF LIME TESTS

Field	Liming material	Date Applied	Date Applied	Reaction of Rates				
				1 Ton	2 Tons	4 Tons	3 Tons	6 Tons
Anderson	France	Sept., 1922	June 19, 1923	S. acid	S. acid	Neutral	....	....
Beardsley	"	"	July 11, 1923	M. acid	S. acid	....	Neutrai	....
Curtis	"	"	June 18, 1923	....	S. acid	Neutral	....	....
Gibson	"	"	July 11, 1923	....	....	S. acid	S. acid	S. acid
Jensen	"	"	July 10, 1923	....	S. acid	Neutral	....	....
Lippert	"	"	July 5, 1923	M. acid	Neutral	Neutral	....	....
Morgan	"	"	July 10, 1923	S. acid	Neutral	Neutral	....	....
Rowe	"	"	June, 1923	S. acid	Neutral	Neutral	....	....
Stewart	"	"	"	S. acid	S. acid	Neutral	....	....
Tefft	"	"	July 5, 1923	M. acid	Neutral	Neutral	....	....
Tew	"	"	June, 18, 1923	S. acid	Neutral	Alkaline	....	....
Welch	"	"	July 10, 1923	S. acid	S. acid	Neutral	....	....
Wilnow	"	"	June 19, 1923	Strongly acid	M. acid	S. acid	....	....
Wilson	"	"	June, 1923	S. acid	S. acid	Neutral	....	....
Mancelona	Petoskey	June, 1922	June 20, 1923	S. acid	....	Neutral	....	....
Mancelona	Solvay	"	"	Neutral	Neutral	....	Alkaline	....
Mancelona	Hydrate	"	"	500 lbs. S. acid	1000 lbs. Neutral	3000 lbs. Alkaline	....	....

S. acid=slightly acid; M. acid=medium acid.

In the Thumb area and Saginaw Valley twenty-two sugar beet projects were established. The objects being to determine the rate and kind of fertilizers and methods of application, special emphasis is made on the amounts of phosphate and potash. The fertilizers were applied with the seed, over the seed, under the seed and on each side of the row and broadcasted and worked in before planting.

During the year samples were taken of alfalfa on various fields under different fertilizer treatment and analysis run to determine the effect of fertilization on the protein and mineral content of the hay. A preliminary report was made in the May 1923 Quarterly. This work has been expanded to include the analysis of sweet clover and alfalfa on seven fields in northern and southern Michigan on fifty-six different fertilizer treatments.

In charge of G. M. Grantham, the investigations on commercial fertilizers in western Michigan include the use of various brands of ready mixed goods; high and low analysis, goods applied in equal pound rates per acre and equal money values per acre; single ingredients, special attention being given to nitrate of soda, sulphate of ammonia, acid phosphate, flowers of sulphur, calcium sulphate, and American and French potashes. Different rates of applications as well as different time and methods of application constitutes the greater bulk of this fertilizer work.

The various forms of lime, including fine and coarse ground limestone, hydrated lime, sugar factory refuse lime and marl are being used. Invesigations are under way in order to determine how deep in the soil lime may be for plants to make use of the same and in addition is applied in the row with the seed.

Each year sees an increase in the interest and use of green manure practices for soil improvement; accordingly different crops are being turned under for such purposes. In some cases the seed is removed before turning back the residue, while in others the green crop is turned under.

Some striking results have been obtained by liming and fertilizing on various soil types. In Kalamazoo county, on a Fox sandy loam, which has been farmed for a number of years, an application of 200 lbs. of acid phosphate and 100 lbs. of muriate of potash on alfalfa caused an increase of 1937 lbs. of hay over an unfertilized area. The same soil when unlimed will not produce alfalfa.

On the Cass County farm on a Fox sandy loam, lime alone has increased the yield of sweet clover 4,451 lbs. green weight. Where lime, acid phosphate and potash was applied the yield amounted to 7,648 lbs. green weight, more than was produced on an untreated area. For legume crops, such as alfalfa and sweet clover, lime and potash seem at the present time to be quite essential. The residual effect of both materials over a rotation is quite marked.

On light to medium light soils in both southern and northern parts of the State, nitrogen in combination with acid phosphate has made some very profitable returns. The use of nitrate of soda or sulphate of ammonia as a top dressing in the spring on fall seeded grains on light soils has been quite profitable. In thirty trials to the present time using nitrate of soda or sulphate of ammonia as a top dressing, has averaged 5.1 bu. increase. Oats have responded profitably to the use of nitrogen and phosphate in spring applications.

The most profitable material applied to corn on all soil to the present time is acid phosphate. It is not uncommon for an application of acid phosphate to increase the yield of corn 12 to 15 bu. per acre.

The field investigations on muck soils in charge of Dr. P. M. Harmer have progressed and are on a sound basis. During the year studies were undertaken on projects. These investigations included the time, manner and combination of mineral fertilizers to apply for the production of the common field crops and different vegetables. Considerable energy has been spent on the factors that affect the yield and quality of oil in peppermint and spearmint. In some instances the use of muck fertilizers resulted in a lower oil production whereas in others it resulted in striking and profitable increase. In some cases acid phosphate was all that was needed to cause satisfactory production but usually fertilization with potash was essential and in still others both acid phosphate and potash were needed. Climate plays a tremendous role in the manufacture of oil by these plants. Experiments to determine the effect of rolling or comporting of muck soils on crop production and moisure and nitrate relationship were inaugurated.

Dr. Bouyoucos studied the degree of change brought about in soils by igniting them at different degrees of temperature. As a measure of this change three distinct physical properties were used for comparative study. These are heat of wetting, unfree water, and plasticity. The temperatures used were 110°C, 170°, 230°, 485° and 850°. The results obtained show that no appreciable change in the above properties takes place until the temperature of about 230° is reached. This is about the initial temperature where a change commences to take place in all three properties. This change increases in degree until about a temperature of 800°C is reached where it is completed and the properties of heat of wetting, plasticity and unfree water are almost or completely destroyed and they disappear.

He has found that different soils deplay marked degree of physical reaction. Two soils, for instance, may be exactly alike in texture and structure and yet they may have greatly different reactivity towards water. Our investigations as to the cause of the difference in reactivity seem to show that it is due to the difference in activated surfaces in the soils. In other words, the surface of one soil particle may be inert or inactive, while that of another is active. Hence the reactivity of the former will be greater than that of the latter.

The study of the factors governing structure and plasticity in soils has yielded very interesting results and some new theories have been evolved to explain the property of plasticity. It would take too much space to present in this report the results and theories.

Considerable chemical research work has been done during the year. Spurway has examined the horizons of several soil types in attempting to obtain basic information on the factors that cause soil variation as well as the variations in the media in which crops grow. It has been brought out that the solubility of acid phosphate varies greatly when applied to soils of different constitution both naturally and artificially. His perfection of the Soiltex method for determining the reaction of soils has been favorably received by county agents, numerous farmers and several investigators in other States. When properly made use of this method is very valuable and has and no doubt will in the future do much toward bettering soil conditions in the State. Weidemann has found tremendous differences in the ability of muck soils to fix phosphorous and potassium which is contrary to the popular conception that all soil organic matter is effective in holding various elements of plant food. His physical studies have furnished us with information of value in the classification of muck soils. It is evident that the classification of such on the basis of original plant material is not ample in as much as horizons have developed in many through their weathering.

The chemical studies of alfalfa and sweet clover grown on several of our experimental fields, differently treated, have shown that their composition and consequently their feeding value may vary appreciably when grown on different soil types, and that the use of lime and other materials may affect them also. The sugar and impurities in sugar beets grown on muck soils have been determined in a number of instances, as previously reported, these are governed to a very great extent by the relationships. It is both possible and practicable to produce large yields of beets of acceptable sugar content and purity on many of the muck soils of the State.

Respectfully submitted,
M. M. McCOOL,
Professor of Soils.

To the Director:

Sir:—The following is a report of work done on the Upper Peninsula Experiment Station during the year ending June 30, 1923:

LAND CLEARING.

The land clearing work has progressed quite rapidly. The E½ of NE¼ of Sec. 34 was cleared and 25 acres plowed. Twenty acres of this was cropped this year. Twenty acres adjoining this tract on the south is now ready to plow. Seventy and one-half acres of the E½ of NW¼ of Sec. 34 is approximately one-half cleared. The plan was to have this completed but a large number of the land clearing crew left for the lumber camps, consequently the balance of the clearing was postponed. The clearing on the W½ of the NW¼ was completed and put into crops. The stumps were blown out on the two acres in the 40 acre tract E of the Station buildings. Altogether there were 121 acres cleared, and 27 acres of new land put into crops during the past year.

When the above described 70½ acres is completed, a field on the 40 acres across from the Station buildings squared up, and a cedar stump area along the Bohemian creek in the SW¼ of Sec. 34 cleared, the land clearing program for this Station will have been completed. This will give approximately 400 acres of cleared land, of which about 375 acres can be cropped. It is estimated that this tract will provide sufficient area for experimental crops and plant disease work, and supply winter feed for the livestock that the uncleared areas will pasture.

WOOD LOTS.

There are 19.7 acres in the wood lot on the home farm, 11.4 acres on the 40 acres across the road, and small cedar areas along the Slapnick and Bohemian creeks.

FENCES.

There are now 10¾ miles of woven wire fences on, or enclosing, Station property. In order that this program be completed 1¼ miles of fence will have to be built in the near future.

DRAINAGE.

During the year, 160 rods of open ditch were constructed by use of dynamite at a cost of $.76 per rod. Considerable tile drainage is necessary on the S½ of SE¼ of Sec. 28.

BUILDINGS

A powder magazine, 8′ x 8′ was erected in the wood lot north of the dairy barn. It is a double wall construction, a two inch plank being used with a six inch sand lining. The top is of the same material. This provides a much needed safe store-room for explosives.

The office building, the sheep barn and silo were given a coat of paint.

Drinking cups were installed in the dairy barn.

All buildings were wired and a single unit Kohler lighting plant has furnished power. This has given the best of satisfaction.

MACHINERY.

A 12-20 Cletrac tractor, breaking plow, two bottom plow, double disc harrow, spring tooth harrow and some small tools were added to the Station equipment.

LIVE STOCK.

Dairy. The dairy herd now consists of 14 milking cows, 7 heifers, 3 bull calves, and one herd sire. The milk and cream were sold in Marquette, Munising and Chatham. The surplus stock was sold to farmers in the Upper Peninsula. Semi-official testing has been conducted with six of the cows. The herd is on the tuberculin accredited list.

The average milk production of the herd during the past year was 14,484 pounds. The highest individual record was 21,372 pounds of milk and 649.8 pounds of butter fat.

Sheep. The Station flocks of sheep now total 435 head, consisting of Hampshire, Rambouillet and Shropshire, with grade and cross-breds of the above breeds. Records are kept of the breeding, of the individual weights at birth, at shipping time in the fall and as yearlings; also of the weight of fleece, number of lambs, etc. The wether lambs, cull ewes and cull ewe lambs were marketed in Chicago.

CROPS.

Approximately 71 acres are devoted to experimental crops, plant disease work and seed increase. The balance of these are under cultivation, producing hay and grain for livestock feeding. Reports of the plant disease and crops experimental work follow.

POTATO DISEASE WORK

BY J. D. KOTILA

Herewith report of work carried on by the Botany Section of the Michigan Agricultural Experiment Station at the U. P. Experiment Station during the fiscal year ending June 30, 1923.

As in preceding years, the work was confined primarily to investigation of potato diseases. Approximately 7 acres of land were devoted to experimental work.

Three acres of the south farm were devoted to an experiment to determine the relative efficiency of Bordeaux mixture and copper lime dusts on Green Mountain potato vines. A four-row power sprayer was compared to a four-row power dusting machine. The season was favorable to leafhoppers, and hopperburn was abundant. This trouble and Early Blight disease, which became epidemic early in September, were factors which reduced the yield to the unsprayed plots very materially. The Bordeaux plots which were sprayed six times during the season remained green much longer than the plots which had received a like number of applications of copper-lime dust. The Bordeaux plots likewise outyielded the dusted plots.

Unfavorable results having been obtained during the 1921 season on the control of potato scab with applications of sulphur to the soil at the rate of 300 pounds per acre, the 1922 experiments represented trials of sulphur applied at higher rates,—400, 600, 800 and 1200 and 1600 pounds per acre. Three acres of Rural New Yorker potatoes were devoted to these experiments. There was no noticeable effect on stand or vine growth during the growing season. The data obtained at harvest indicated that scab was not controlled by applications of inoculated sulphur to the soil at the rates of 400, 600, or 800 pounds per acre. The data from the plots which received 1200 and 1600 pounds of inoculated sulphur show a lower percentage of scab but this reduction was counterbalanced by a higher percentage of sulphur injured potato tubers.

An area of approximately half an acre was planted as a show plot with potato seed stock affected with various diseases,—mosaic, leaf roll, streak, rhizoctonia, etc., in order that anyone interested might be able to study the symptoms of the more common potato diseases.

Several isolated plots were planted with tubers of various varieties which had been indexed in the greenhouse during the 1921-22 winter. The vines remained healthy throughout the season and the progeny was saved for increase during the 1923 season.

I thank you for the interest you have shown and the hearty co-operation you have given to facilitate the work of the Botany Section during the past season.

CROPS WORK

BY H. R. PETTIGROVE.

The progress of the Crops Experimental work at the Upper Peninsula Experiment Station for the year ending June 30, 1923 was as follows:

Varietal testing of small grains was continued as before including oats, barley, spring wheat, winter wheat, and peas. Another series was added to the list to include flax and combination grains of flax, oats, barley, and wheat. There was also a series of combination grains including oats and peas at different proportions of each.

A rate of seeding tests was carried on with the English Field peas and the Cloverland Soup pea.

Cultural work in potatoes was continued as in previous years. Hill unit selection of different strains were compared and yields obtained. Distance of spacing of the White Rural, Irish Cobbler, Early Ohio and Green Mountain were compared for yield. White Rurals were used in comparing the size of seed piece as affecting yield in different spacings, the number of potatoes and their size as well as the area occupied being a constant.

Sunflowers were tested for distance of spacing and rates of seeding.

A series of Red Clover strains were tested to determine the relative merits of seed coming from states in the United States and foreign countries.

The annual hay crops were continued as previously with the addition of a rate of seeding of the oats and peas combinations and a seeding of millet and pea, also millet and vetch combinations. Late seeding of oats usually rusts badly with the resultant loss of most of the leaves and panicle, it being possible that the millet may substitute for the oats.

A series of alfalfa cuttings was begun to determine yield and effect of time of cutting upon the stand and the plants over a period of years.

The increases consisted of potatoes, oats, barley and peas. The potato increase was small. The oats covered a sulphur plot of the year previous that samples might be obtained to determine the effect of sulphur upon the oats. The plot was also seeded to clover. The pea increase consisted of a few Alaska and the rest of the English Field peas.

Co-operative work was continued on the Wetmore sands and the Seney muck soils. The former to develop a rotation or system of farming to build up the sands and the latter to find stable crop for the muck lands.

Very truly yours,
D. L. McMILLAN, Supt.

REPORT OF THE DIVISION OF EXTENSION WORK

To the President:

Sir:—The work of the Division of Extension Work is administered through the leaders of the various projects which have been appointed by the Secretary of Agriculture in accordance with the terms of the Smith-Lever Act. The leaders of these projects are required to report annually to the Federal Department of Agriculture for each complete season's work on December 1st. The fiscal year ending June 30th, is not an appropriate date for reporting upon work which is dependent upon the growing season for completion. For this reason the reports which follow are for the year ending November 30th, 1922, rather than for the fiscal year. The following projects have been effective for the period named and the reports are appended hereto:

1. Administration and Publications.
2. County Agricultural Agents.
3. Home Demonstration Agents.
   3. (a) Home Management.
   3. (b) Clothing and Textiles.
   3. (c) Foods and Nutrition.
4. Boys' and Girls' Clubs.
5. Farm Crops.
6. Dairy Husbandry.
7. Animal Husbandry.
8. Horticulture.
9. Potato Culture.
10. Soils.
11. Farm Management Demonstration.
12. Insect Control and Apiculture.
13. Drainage and Household Engineering.
16. Marketing.
17. Poultry.
18. Land Clearing.

Effective working relationships with all college departments have been continued throughout the year. Department heads without exception are recognizing and meeting their responsibilities in connection with developing a potent and dependable extension service through the specialists employed within their departments.

A relationship of mutual helpfulness continues to grow between the Extension Service and all farm organizations but the active and official co-operative relationship is with the local County Farm Bureaus as contemplated in Federal and State Laws. In theory this relationship is beneficial to the College in bringing its workers into personal contact with rural people and helping to adjust the service they give to their needs and wishes and beneficial to the rural people in securing their interest and support in a program which they take in part in formulating and assist in carrying out. In practice this theory has been proven to be sound and ten years of this kind of co-operation has given the State a powerful agricultural program in which the College is taking a very strong part.

During the year many local County Farm Bureaus have conducted membership campaigns. The outcome of these has a direct effect upon the Extension Service because the resulting funds are used to assist in the employment of County Extension Agents. The total membership being secured is not as large as formerly and consequently less funds are available for the support of the county extension organization. It is encouraging, however, to know that the new membership includes much of the intelligent, progressive element of rural people; those who are capable of leadership in agricultural work and thought. This is of greatest importance because of the need for active co-operation on the part of the farmers through their organizations in determining the program of work and in carrying it out effectively.

The present period of economic imbalance between agriculture and other industries has increased the difficulties of maintaining all lines of work in some of the counties. The appropriations by Boards of Supervisors have been continued, though diminished in some cases. This, together with the fact that the funds available from the county bureaus are less, may cause a decrease in the number of home and club agents but no great decrease in agricultural agents is anticipated.

Publications:

6,000 Extension Course Notes No. 29—4 pages—"Food for the Baby, 1st year"—Home Economics.
6,000 Extension Course Notes No. 30—2 pages—"Food for the Baby, 2nd year"—Home Economics.
7,000 Extension Course Notes No. 31—2 pages—"Food for the Pre-School Child"—Home Economics.
6,500 Extension Course Notes No. 32—2 pages—"Food for the School Child"—Home Economics.
20,000 Extension Bulletin No. 23—4 pages—"More Alfalfa for Michigan"—H. C. Rather.
20,000 Extension Bulletin No. 25—4 pages—"Feeding Cull and Surplus Potatoes"—J. W. Weston.
10,000 Extension Bulletin No. 26—12 pages—"Swine Feeding—V. A. Freeman.
8,000 Extension Bulletin No. 27—8 pages—"Kitchen Sink"—O. E. Robey.
10,000 Extension Bulletin No. 28—4 pages—"Feeding for Egg Production"—E. C. Foreman.
20,000 Extension Bulletin No. 29—8 pages—"The Baby Chick"—E. C. Foreman.
5,000 Extension Bulletin No. 30—4 pages—"The Production of Hardigan Alfalfa Seed—H. C. Rather.
10,000 Club Bulletin No. 9—62 pages—"Sewing"—Elda Robb and Barbara VanHeulen.

10,000 Club Bulletin No. 10—44 pages "Canning"—Barbara VanHeulen.
4,000 Club Bulletin No. 2—16 pages—"Potatoes"—H. C. Moore.
3,000 Club Bulletin No. 4—12 pages—"Organization of Calf Clubs"—Nevels Pearson.

An extension office of publications is maintained in charge of an Extension Editor who edits all publications and supplies a news and information service to the weekly, daily and farm press. From three to five articles per week are sent to 375 weekly papers having a combined circulation of over 500,000. The ninety daily papers are furnished with articles at least once each week and more often several during that time.

Fourteen newspapers publish "Farm Pages" and these are furnished with from 1,000 to 2,500 words of copy once a week. The combined circulation of these "farm pages" is approximately 300,000. Special articles are sent to the farm papers on all special occasions. The Associated Press, United Press and International News Service are furnished with news on an average of twice per week.

Appointments:

Name. Title. County. Date.

Joe Turner, County Agr. Agent, Delta, July 1, 1922.
Ralph J. Carr, County Agr. Agent, Wayne, Sept. 16, 1922.
L. R. Binding, County Agr. Agent, St. Joseph, Sept. 16, 1922.
O. I. Gregg, County Agr. Agent, Allegan, Sept. 16, 1922.
J. W. Sims, County Agr. Agent, Tuscola, Sept. 16, 1922.
C. E. Atwater, County Agr. Agent, Grand Traverse, Sept. 16, 1922.
Roy Weinberg, County Agr. Agent, Hillsdale, Dec. 1, 1922.
Bishop Adams, County Agr. Agent, Calhoun, Mar. 1, 1923.
Art Lonsdorf, County Agr. Agent, Dickinson, Feb. 16, 1923.
C. M. McCrary, County Agr. Agent, Alpena, Feb. 1, 1923.
I. J. Sours, County Agr. Agent, Presque Isle, Mar. 16, 1923.
H. M. Vaughn, County Agr. Agent, Manistee, Mar. 16, 1923.
Errol S. Bird, County Agr. Agent, Kalkaska, Mar. 16, 1923.
Clare L. Burton, County Agr. Agent, Monroe, Apr. 16, 1923.
Ralph L. Helm, County Agr. Agent, Ionia, May 1, 1923.
L. J. Carter, County Agr. Agent, Arenac, May 1, 1923.
Carl H. Knopf, County Agr. Agent, Muskegon, May 16, 1923.
Karl Knaus, County Agr. Agent, Menominee, June 16, 1923.
J. W. Wagner, County Club Agent, Wayne, July 16, 1922.
Harold Canfield, County Club Agent, Lapeer and Macomb, Sept. 1, 1922.
A. M. Shaw, County Club Agent, VanBuren, Mar. 16, 1923.
G. S. Hedrick, County Club Agent, Lenawee, Apr. 16, 1923.
F. M. Karn, County Club Agent, Lapeer and Macomb, Apr. 16, 1923.
Murial Dundas, Home Demonstration Agent, Allegan, July 16, 1922.
Ruth Wheatley, Home Demonstration Agent, Gogebic, Sept. 16, 1922.
Bernice Woodworth, Home Demonstration Agent, Wayne, Oct 16, 1922.
E. G. Amos, Asst. Co. Agt. Leader, Upper Pen., Nov. 16, 1922.
Ida Sichler, Asst. St. Leader, H. D. A., Nov. 1, 1922.
Adele Koch, Asst. St. Leader, H. D. A., Nov. 1, 1922.

Verne Freeman, Livestock, July 1, 1922.
A. J. McAdams, Land Clearing, July 1, 1922.
Stanley J. Brownell, Dairy, July 1, 1922.
George Amundson, Land Clearing, July 1, 1922.
Ray D. Ure, Poultry, Sept. 1, 1922.
Eunice Ryan, Clothing and Textiles, Oct. 1, 1922.
Marian Rogers, Home Management, Oct. 1, 1922.
J. G. Hays, Dairy, Nov. 1, 1922.
R. Addy, Dairy, Dec. 1, 1922.
H. A. Cardinell, Horticulture, Jan. 1, 1923.
J. G. Wells, Dairy, Jan. 1, 1923.
Karl H. Miller, Dairy, Jan. 1, 1923.
George Starr, Farm Crops, Feb. 1, 1923.
Larry D. Kurtz, Farm Crops, Apr. 1, 1923.
George Starr, Horticulture, Apr. 9, 1923.

Temporary County Club Agents:

Agnes Martin, Eaton.
A. M. Myrhman, Dickinson.
K. P. Silberg, Gogebic.
G. Shipps, Midland.
D. V. Steere, Presque Isle.
M. R. Kimball, Clinton.
Alice Zeno, Alger.
George Kimball, Jr., Oakland.
M. R. Cameron, Luce.
W. S. Wood, Jackson.
L. H. Matthias, Hillsdale.
Goldie Benham, Barry.
Alfred Rood, Houghton.

Resignations:

Name. Title. County. Date.
Alex MacVittie, County Agr. Agent, Tuscola, July 31, 1922.
Alfred Bentall, County Agr. Agent, Allegan, Aug. 31, 1922.
A. J. Hutchins, County Agr. Agent, St. Joseph, Aug. 31, 1922.
C. E. Atwater, County Agr. Agent, Gladwin, Sept. 16, 1922.
O. I. Gregg, County Agr. Agent, Wayne, Sept. 16, 1922.
J. W. Sims, County Agr. Agent, Hillsdale, Sept. 16, 1922.
Paul H. Smith, County Agr. Agent, Missaukee, Dec. 31, 1922.
R. M. Roland, County Agr. Agent, Calhoun, Dec. 31, 1922.
V. C. Vaughn, County Agr. Agent, Leelanau, Dec. 31, 1922.
Irving Kirshman, County Agr. Agent, Menominee, Nov. 30, 1922.
C. M. McCrary, County Agr. Agent, Presque Isle, Jan. 31, 1923.
Harry L. Carr, County Agr. Agent, Ionia, April 30, 1923.
C. W. Wing, County Agr. Agent, Osceola and Lake, April 20, 1923.
Carl H. Knopf, County Agr. Agent, Manistee, Mar. 15, 1923.
Dwight C. Long, County Agr. Agent, Muskegon, Mar. 15, 1923.
B. Eldon Shaffer, County Agr. Agent, Montcalm, June 30, 1923.
A. G. Bovay, County Agr. Agent, Saginaw, June 30, 1923.

C. L. Nash, County Agr. Agent, Branch, June 30, 1923.
Karl H. Miller, County Agr. Agent, Dickinson, Dec. 31, 1922.
C. O. T. Scheetz, County Agr. Agent, Alpena, Oct. 31, 1922.
Jennie Williams, Home Demonstration Agent, Gogebic, Aug. 31, 1922.
Murial Dundas, Home Demonstration Agent, Gladwin, July 15, 1922.
Marian Rogers, Home Demonstration Agent, Wayne, Sept. 30, 1922.
L. W. Ross, County Club Agent, Wayne, Sept. 1, 1922.
L. E. Mericle, County Club Agent, Genesee, Mar. 15, 1923.
Harold Canfield, County Club Agent, Lapeer and Macomb, Apr. 15, 1923.
Marjorie Place, County Club Agent, Lenawee, Apr. 15, 1923.
Helen Arms, Clothing, Sept. 16, 1922.
Edna V. Smith, Asst. H. D. A. Leader, June 30, 1923.
Barbara Van Heulen, Asst. St. Club Leader, June 30, 1923.
Karl H. Miller, Dairy Specialist, June 30, 1923.
C. M. Ferguson, Poultry Specialist, June 30, 1923.

Yours very truly,
R. J. BALDWIN,
Extension Director.

REPORT OF COUNTY AGRICULTURAL AGENT PROJECT.

R. G. CARR AND C. V. BALLARD.

1. Organization of Extension Work in the Counties:

1922 has seen no radical changes in the plan of organization used in carrying on Agricultural Extension Work within the counties of Michigan. However, the extreme economic condition as felt by farmers of the state makes it difficult in many instances for farmers to support extension work through Farm Bureau memberships. As a result there appears to be a growing tendency toward public appropriations. The State office has encouraged this tendency on the grounds that the work is for public benefit and, therefore, should be supported largely from public appropriation.

Each County Agent is required to submit a County program of work. The form of this program, as suggested by the State office, was simple and direct, the plan being to get a general idea of the most pronounced Agricultural problems as seen from the various counties, to get local ideas as to their solution, to find out what progress the County Agents hoped to make towards the solution of these problems and to get an estimate of the percentage of the Agents' time or attention which each project would receive. These programs of work were formulated by the County Agent in council with his Farm Bureau Executive Committee and with representatives of other co-operating bodies in some instances. Where possible, supervisors from the State office sat in and advised concerning these programs of work, while they were in the making.

Upon receiving the full list of programs from the various county agents the State supervisors were able to check up and advise in both subject matter and balance of these programs. Several changes were made as a result of suggestions from the State office. Aside from the assistance which could be directly rendered agents through this service, the State office was able to so arrange specialists' schedules as to make it possible for the agents to carry out their programs and at the same time make more efficient use of the specialists' time.

If the number of communities, in which County Agents in Michigan have consulted some of the leading farmers concerning the agricultural problems and a plan formulated to carry on some particular line of work, leading to the solution of these problems, could be considered communities in which programs have been developed, it could be safely said that every county in Michigan has made progress in the development of community programs and at least 600 communities have programs adopted according to this plan.

We have maintained that the working out of a community program should be a development process, rather than a spontaneous one. We believe it to be a mistake to try to work along too many lines in a county. Also, that a recognized job should precede the organization necessary to carry it out and that no more organization should be formed than necessary to do the work at hand. We believe each job undertaken should be of such a nature that progress on it could be measured and understood by the average farmer of a community.

An example of the development of a community program may be seen in reviewing the extension work which has been done in the community surrounding the village of Parma, in Jackson county. Ten years ago last Fall the first bushel of Rosen Rye to be sent out from the College Experiment Station went to a farm in that community; due to the persistent efforts of the extension department in promoting the Crop Improvement Association, the entire community is now growing Rye of that variety. In fact, a survey of the situation taken through the local elevators show that over 95 per cent of the rye grown in this county in 1922 was Rosen. The benefits derived from this variety of rye paved the way for other pedigreed grains, such as Wolverine Oats, Red Rock Wheat and Robust Beans. The introduction of pedigreed grain in this particular community proved of great advantage to the county agent, when that branch of extension work was introduced in this county. A Co-operative Livestock Shipping Association was organized and shortly afterwards a co-operative elevator was also organized. This was followed by the organizing of a Community Club, which included both Rural and Urban people and dealt with problems which were of mutual interest. While the Extension Department had no direct connection with the forming of this organization, the fact that the farmers had been previously brought together into the other organization mentioned, doubtless, paved the way to the Community Club and it was this last named organization which was induced to become actively interested in the promotion of the county-wide Tuberculin Test on cattle. It is interesting to note that it was in this community that the area plan was started in controlling Bovine Tuberculosis in the county. After the county-wide Tuberculin Test had been put across a Cow Testing Association was organized, then the community became interested in promoting Guernsey cattle and a breeders Association was organized to promote the breed.

We believe that the fact that one thing at a time was undertaken and shortly after completed, has had a wholesome effect on the agricultural progress in that community.

The county program, as adopted by most of the County Agents in Michigan, only includes those projects which deal with commonly recognized agricultural problems of the county. In many instances a campaign method was employed in carrying out these programs. The plan and results of this method of doing extension work is reported by specialists in charge of extension work in this state. County Agents are quite generally of the opinion that this method of doing extension work has been highly satisfactory. The results attained will bear out their contention. It has been found that through this system of doing extension work, for example, the dairy and alfalfa work has received a great deal of impetus, which has not been supplied entirely by either the county agent or specialist in charge of the work. The fact that hundreds of farmers are caused to discuss one common subject at one particular season, brings results that a less concerted effort could not hope to accomplish. A typical county program is given below:

COUNTY PROGRAM OF WORK

Big problems in county listed in order of relative importance this year.	Solution	1922 activities towards solution	Percent of time to be spent on each in 1922, est.
1—Live-stock improvement..	Pure-breds and grades.. Cow-testing T. B. eradication	Expect to organize:: 12 Pig Clubs 2 Sheep Clubs 1 Holstein Club 1 Shorthorn Club Dairy Campaign followed up by Cow Testing Assn., T. B. Campaign and Bull Assn.	50%
2—......................	Bull Association		
3—Crops Improvement.....	Alfalfa Culture Certified Seed	Alfalfa Campaign Expect to organize: 5 Corn Clubs 2 Bean Clubs 2 Potato Clubs Variety demonstrations in field—Oats, Corn, Barley Beans, Alfalfa, Potatoes, Sweet Clover	30%
4—Home Improvement.....	Better Foods Better Clothing	Expect to Organize: 8 Canning Clubs 5 Garment Clubs 8 Handicraft Clubs	20%

REPORT OF HOME ECONOMIC EXTENSION WORK.

BY DEAN LOUISE H. CAMPBELL.

Organization of Extension Work in Counties.

Very little change has been made this year in the type of organization in counties having home demonstration agents. Each agent is working constantly to strengthen her organization to make it more permanent and more useful.

The general plan is this—to have one or more chairmen in each township chosen by the women of the township. These women are to act as local leaders in the township as well as to represent the women at the county annual meetings. At the county meeting a county committee is chosen consisting of from three to five members. The chairman of this committee usually represents the women on the county Farm Bureau Board.

Local leaders are taking more and more responsibility in all counties with home demonstration agents, both in putting across programs and in arousing interest in the work. In most all counties money was unanimously appropriated this fall. In one county it was turned down by the Board of Supervisors; however, because of the strong appeal made by the women it was reconsidered and money appropriated. Although the majority of the women are interested in having the work continued, this action would not have been possible had it not been for the local leaders.

Much stronger and better community programs for extension work are constantly being developed with the assistance of the local leaders. They are working out programs on a year's basis in many cases and at least part of a year in most communities.

Approximately every county which is carrying on home demonstration agent work has from five to twenty-four communities in which an extension program is being carried on. In Kalamazoo county each township is represented by one or more organized groups. This is practically true of Allegan, also of Marquette. In the rest of the counties it is not quite as general although there are several communities in different sections which have adopted their definite programs, usually according to immediate needs.

There are seven counties with some communities having definite program, and approximately 135 communities with definite program.

Undoubtedly the best example we have of a good county program development is in Allegan county. At the annual meeting of the Women representing the home demonstration work, quite definite projects were chosen for the county, on the basis of what seemed to be the greatest need for the year, according to the judgment of the representatives of the different townships present. In most cases this had been discovered at the township meeting. Following this meeting each township then decided definitely upon one or more projects.

Each local leader took some responsibility in planning this work, as well as in collecting reports and tabulating results. Where the work became more than she could handle, project leaders were chosen to assist with the different projects. Very definite results were shown as to what can be accomplished in both the dress form and millinery work done in this county. Six meetings were held for training local leaders. Each leader returned to her home community and presented the work. As a result of this, 341 dress forms have been made and are continuing to be made, but the agent has been relieved of all responsibility.

In millinery five training meetings were held, and as a result 280 hats were reported as made and 9 remade with an estimated saving of $951.78.

Each county has at least one county wide meeting during the year at which time results of work accomplished are presented by local leader or some individual who has been carrying on the work. Occasionally this is made into an Achievement Day and work is displayed which has been done by the women themselves, as remodeling hats, dresses, fireless cookers, etc. In some of the counties in the upper peninsula without home demonstration agents, Housewives' Conferences were held which were most successful.

Because so very little planned work was being done in the counties without home demonstration agents excepting a talk now or then, a new plan has been worked out and has been put into effect since September. It is as follows:

A letter was sent to each county agricultural agent stating the type of work to be presented from the home demonstration department. If he were interested in including the home as a part of his program, he with a committee of women, selected the subject they preferred. Then the Specialist presenting this particular subject meets with two different communities in the county once a month for a series of five months, thus giving the women of these communities some really intensive work on one subject. If there has been sufficient publicity and enough interest aroused in other communities, at the end of the series a meeting for training local leaders will be started, making it possible to spread the work to all parts of the county. Our ambition is, of course, to eventually interest them in home demonstration work. At the present time about 30 counties have asked for the work and several counties are talking of the possibility of a home demonstration agent just as soon as there is some improvement in the financial situation.

SUPERVISORY PROGRAM.

Strengthening the organization in the home demonstration agent counties and helping the women to see the necessity for training local leaders to assist in carrying one some of the projects has been the primary job of the State Leader throughout the year. This has been accomplished principally at county-wide meetings. Each county has an annual meeting, some semi-annual, and quarterly.

Direct supervision of the home demonstration agent is always necessary to a certain extent. This has been done by office visits at which time conditions, policies and methods have been discussed.

The Assistant State Leader located in the upper peninsula has had most of the supervision of the home demonstration agent as well as carrying on definite projects in at least four other counties.

All county offices, although far from ideal are becoming more and more satisfactory, with more records and more reports which makes it much easier for a new agent taking up the work in the county. As a rule there is never more than one stenographer in the extension office which many times hampers the work in that it makes it necessary for the home demonstration agents to give up time to things which could well be taken care of by the secretary. In many cases this lack of sufficient help is being overcome by the addition of improved systems and improved equipment. This improved equipment applies as yet more to the office than it does to any demonstration equipment to be used by the agents in the field.

The many changes which have been made in the personnel of the county extension forces have been responsible to quite an extent for the improved condition especially as far as records are concerned. In the case of new home demonstration agents they are always brought into the state office for a few days, varying from three days to two weeks, at which time the necessity of records and reports is emphasized from the state standpoint as well as county.

At the state conferences which are held once a year and often times twice a year, reports and records are discussed. Methods and organization are always considered, and usually some subject matter is given by some of the Specialists.

A most splendid policy is being worked out this year in regard to the relationship between the resident teachers and the field workers. They are all called together for departmental faculty meetings. The Extension people hear the discussion in regard to policies and subject matter and the teaching force hears the field problems discussed. Each helps the other in many ways.

Undoubtedly one of our greatest faults in past years has been the lack of proper analysis of conditions and needs in our counties by the home demonstration agents guided by the State Leader and her Assistant, and then a follow-up showing the results accomplished. This condition has been recognized, however, and a much greater effort will be made during the coming year to overcome this failing by getting each agent to make a survey of her county and then to make an analysis of the county as to its needs. This will make it possible to work out a long time program and to follow up each step with records to show the progress being made.

PUBLICITY.

No real definite plan of publicity has been carried on from the state office. During the early part of the year a series consisting of two articles was written by each Specialist for the Lansing State Journal. The same articles were used in other papers throughout the state. Occasional articles have been written for the Michigan Farmer, a paper which goes into nearly every farm home in the state. These articles have consisted of accounts of results accomplished as well as subject matter popularized.

Each home demonstration agent has taken care of her own publicity.

It consists of monthly articles written for the County Farm Bureau News also notices for all county papers of work to be given in county and results of work accomplished.

PROJECT ACTIVITIES AND RESULTS.

Foods and Nutrition

The nutrition problem is the ever present and undoubtedly the most important problem to be considered in the home. Because of the great number of underweight children found in our schools today the following plan has been worked out with the idea in mind that it would reach the greatest number in the least time.

A series of stories were written for the school child, one story for each month. They consist of a good growth story, a milk story, a vegetable story, a fruit story, etc., stressing the important foods for a growing child. The stories were presented by the teachers as a local leader. Whenever possible the mothers were invited in to hear the story and asked to co-operate in carrying out the feeding plan.

As a result of this work during the past year very good results have been obtained, statistics of this work being given in report of the Nutrition Specialist.

In one school in a northern county it was reported that the story day was the village event, long looked forward to, all mothers going whenever possible.

The teachers have always reported wonderful improvements in the efficiency of the pupils as a result of this work. This has seemed a much worth while work. It brings to the child the value of certain foods for growth. The mother is often times invited in when the story is given, so her co-operation is secured and in our state has done more than anything else to bring the value of the whole extension work before the people.

Food selection for the pre-school and the school child has been emphasized throughout the year and is the most important part of the discussion for the nutrition work in the series of meetings being held. People all over are thinking and talking in terms of proper nutrition therefore authentic information is essential. Four small leaflets were gotten out during the summer by the Specialist hoping to meet some of the demands for such material. Most of her nutrition work is based on them.

Preservation

This is always being talked,, but very few demonstrations are being held with the exceptions of meat canning. This is a growing project. In a few instances neighbors have gone together and have canned a whole beef at one time, the men cutting up the meat while the women canned. They feel that a substantial amount of money is saved by the canning of their home grown meat besides the convenience and the excellency of the product. In one community an estimate was put on the value of their product and it amounted to about $70. Reports turned in by local leaders from one county showed 124 quarts of poultry canned, 354 quarts of veal and 215 quarts of pork.

Clothing and Millinery

Two main sub-projects of this work were carried on during the year, dress forms and millinery.

Although the dress form work is old it has continued to be one of the most popular subjects throughout the state. Practically every woman wants a dress form and it has seemed one way of helping them to meet the economic situation. This is not far fetched. They have been able to do so much more of their own sewing and in a more satisfactory way than was ever possible before. They can be better dressed on much less money. This project has been promoted almost entirely through the training of local leaders. Usually four women from three communities have been brought together for each training meeting. During the past year about 1,500 forms have been made in the counties with home demonstration agents and about as many in other counties. From now on it will undoubtedly take care of itself excepting in counties where they have had none of the work.

The millinery project has been one which has proven of value especially in meeting new groups. Everyone recognizes the value of the work from a financial standpoint. This has been worked out in practically all cases by means of meetings for training of local leaders. It was carried on during the spring and early summer in eleven counties with 64 communities represented. The training meeting was followed by one day "clinics" conducted by the local leaders in their own communities. As far as possible the home demonstration agents assist with these meetings. The work consisted of making new hats and renovating and remodeling old hats. About two-thirds of them were made-over hats.

On account of the illness of the Clothing Specialist no organized work was carried on from June first to October first. At this time a new Specialist was appointed and clothing work from the standpoint of construction and selection was started. This is being carried on now in eight different counties and fifteen communities—five without home demonstration agents. In two of the counties with home demonstration agents, the agents are taking this into twelve other communities in their respective counties. The plan is to follow this up with round-ups or achievement days at which time the work accomplished will be shown. This work seems fundamental and it is impossible to meet the demand there is for it.

A few individual demonstrations in interior decoration were carried on this year. Most of them were in houses where there was need for this but little money to do with. This has consisted of work in elimination, better grouping of furniture, refinishing of old furniture, etc. It is hoped that this project can be developed more extensively another year.

Household Management

The arrangement of furniture in the kitchens and the studying and planning of expenditures have been the two sub-projects carried through the year. The first has been with the idea of conserving time and energy for the busy housewife without any financial outlay.

The second has emphasized the need for better planning for the expenditures and more of a realization of the value of the food which comes from the farm. Some very interesting material was worked out last year based on the accounts which were kept by some of the farm women. This has proven to be very valuable material during the past year as it brought out the difference in the cost of living on the farm as compared with the cost of living in the city.

Outlook

The general outlook for the coming year is good. Some counties have lost their home demonstration agents within the last two years but each county is talking of the time when the present economic condition has changed so they may be able to have another agent. Several other counties which have never employed a home demonstration agent are looking forward to the time when they may have one. We have felt in the long run it would be much better for us to recognize the financial situation in the counties we have but not to push for new ones this year. However, we hope to make our work just as widespread over the state as we can. We are trying to make all of our work as practical as possible, to make it fit the need of the people and to keep it absolutely fundamental.

Home Management Project, by Edna Smith.

The successful operation of the farm is reflected in the quality and character of the farm home; and in turn the condition of the home is a determining factor in the prosperity of the farm. Any program for advancement of agriculture must, therefore, give proper weight to farm home improvement. It was an appreciation of this fact which resulted in the establishment of the "Household Management" project and the employment of Marion Rogers, October 1st, 1922, as a Specialist in this phase of home service.

The immediate goal in view is the conservation of the time and energy of the housewife by means of better planning arrangement and improved equipment in order that time and energy might be saved for recreation and for thought regarding clothing, nutrition, home beautification, community interests and personal desires. The ultimate result hoped is for a movement towards better farm homes in which a richer and more satisfying family life will be possible, giving permanence and stability to rural life as a whole.

The details of the home service now being offered under this project can be indicated by the following enumeration of subjects being discussed with groups of rural women:

1. Kitchen arrangement.
2. Kitchen and laundry equipment.
3. Running water in the home.
4. Light other than kerosene lamps.
5. Plans for home work.
6. Floor coverings.
7. Budgets (plan of expenditures.)

The county extension agents have organized groups of rural women interested in these problems and these groups are met by the Home Management Specialist once each month. At these meetings full consideration is given to some topic. These meetings are continued until the series of topics are furnished. The women attending the series act as local leaders in their neighborhoods to further disseminate the information.

Clothing Project by Helen Arms.

Millinery was the leading phase of the clothing project from December 1, 1921 to July 1, 1922, judging from the interest in the work. The requests for meetings came in in abundance before the plans for meetings were fully decided upon, so the plan developed and changed with each meeting. It seemed best finally to organize training groups as was done with the dress form work. The nature of the subject prevented definite and satisfactory results as were obtained from the dress form meetings, but enough data was obtained to make possible a more effective plan of work for next year.

County	Attendance	No. of communities represented	Hats	Hours	Cost	Value	Saving
Allegan	30	....	....	....	... ..	......	... ..
Barry	County-wide	....	7	23½	$0.22	$11.25	$11.03
Delta	46	....	22	3 days	32.29	129.66	97.37
Eaton	29	15	26	146½	35.58	142.98	107.40
Gladwin	40	8	26	101½	21.51	93.50	71.99
Gogebic	37	8	37	214½	52.79	225.80	173.01
Marquette	25	3	7	27	4.80	31.50	26.70
Montcalm	15	1	9	19½	2.13	14.25	12.12
Schoolcraft	15	......	6	....	11 18	38 00	26 82
Wayne	42	13	24	4 days	30.06	105 25	75.19
Ottawa	41	13	37	4 days	52.25	161.49	52.25

The dress form meetings continue to be popular. A total of 164 leaders were trained at nine different meetings. At each meeting one or two women were chosen to be responsible for reporting the spread of influence to this office. 474 reports have come into the office since December first. These partly are the result of meetings given previously to that date.

Using the figures secured through questionnaires last fall which placed the value of the dress form at $12.50 each, this means a property value of $1,185.00. These reports are from counties without home demonstration agents and clearly indicate a growth of interest in the work since the reports have come in without solicitation from the office.

Miscellaneous. Two talks were given to high school girls and parents. Three talks were given on extension work at Farm Bureau and Grange meetings. The Specialist worked with the Household Arts Department to prepare demonstration material and exhibits on children's clothing for Farmers' Week, and the Specialist gave the demonstration lecture on that subject. Two weeks were spent at a wholesale millinery house to learn practical millinery methods. The management was extremely helpful and interested in the work.

Two demonstration lectures were given on "Color". Exhibit material on children's clothing was prepared and sent to the institute held at Menominee. The week was spent in conference with Miss Frysinger of the Washington office. Three household Decoration Demonstrations were being carried on in Allegan county.

On October 1, 1922, Eunice Ryan assumed the position of State Specialist on Clothing in Michigan.

The Clothing Project is to be carried on in the following manner: The Specialist will spend two days a month for a period of five months with two groups in each county. These counties have been organized so that the Specialist will meet with the same group of women for five consecutive meetings and carry on a definite plan of work. These Sixteen community groups representing eight counties have been organized by the home demonstration agent or the county agricultural agent.

The aim of the project is to enable the women to do their home sewing by easier and more time-saving methods, and to assist them in proper selection and finishes. In order to do this the plan includes work on: Finishes, Sewing Machine and its Attachments, Patterns (selection, alteration and adaptations), Cutting and Fitting.

As the project is just in its infancy it is impossible to give a definite report. However, if results obtained can be measured by the enthusiasm shown at the first meetings, the results ought to be satisfactory. Cards on the various phases of the project will be given to the women to keep a record of the work.

Home Economics Extension, Upper Peninsula by Ida Sichler.

The present Assistant State Leader came into Michigan on September 15th and spent two weeks at the College in East Lansing becoming acquainted with the extension staff, the program of work, and lower Michigan. The Leader visited Kalamazoo, attended a meeting in that community with the home demonstration agent of that county, judged at the Grand Rapids Fair and at the Reo Fair in Lansing, and also gave a talk at the Woman's Congress at the Ypsilanti Fair. The Assistant State Leader took up her duties at the Marquette office on October first. The first two weeks were spent largely in the office going over files and organizing work.

ORGANIZATION

An attempt is being made to carry on the organized project work in the Upper Peninsula, that is, to have five or six consecutive lessons upon the same subject given in a period of three to six months, depending upon the choice of the community in which it is being given. By carrying on the work in this manner it is thought that the people will be able to see a more direct benefit gained from the work, and the agent can see better results also.

Due to the largeness of the territory in the Upper Peninsula and having only two home demonstration agents at present, it seems necessary that the work of the Assistant State Leader be limited to three or four counties for a period of six months, thus giving intensive work for this period and getting into the remote districts of the county. We cannot expect to establish home demonstration agent work in the county until we are able to put on a detailed program which will reach the majority of the people in the rural districts as well as in villages and locations.

At present, there appears to be four or five counties that are deeply interested in having a home demonstration agent and the work will be centered around those counties largely for the next few months.

CONFERENCES

The third week of October, the Assistant State Leader spent a couple of days in Gogebic county visiting Miss Wheatly, the home demonstration agent. The project outlines were discussed and the various situations that she is finding in her county. Several visits were made to communities where meetings had been scheduled for this time.

The second week of November the county agents of the upper peninsula met at the Marquette office for a two days' conference, at which time the Assistant Leader was privileged to say a few words to the county men. A brief discussion of the project work, aims and methods of co-operation was presented.

CLOTHING

Several communities have had their first or second meeting in the clothing project which consists of a series of five lessons as outlined. There are many demands being made for the millinery work both spring and fall.

NUTRITION

The Nutrition Series is being conducted in about thirty of the rural schools in counties where there are no home demonstration agents. The teachers act as Leaders.

Nutrition Project by Muriel Hopkins.

Beginning with October, changes in the state extension organization affected the nutrition program in quite radical measure. Up to that time it seemed only possible in the main to have single meetings with women on Nutrition. There were three definite exceptions when a consecutive series of meetings covering from four to eight lectures or discussions were held, women enrolling for the course following somewhat the plan of training classes for local leaders. At present the state is so divided that the Specialist is working entirely with definite groups of women having a series of five all day meetings. The plan is as follows:

The Specialist goes to two counties each week. In each county she stays two days, meeting one group of women each day and giving two nutrition lectures—one in the morning and one in the afternoon. The Specialist returns at an interval of four weeks giving two more lectures, etc. The subject for the lectures or discussions are: (1) General Nutrition Knowledge; (2) Feeding the Baby First and Second Year; (3) Process of Digestion; (4) Feeding the Pre-School Child (two to six years of age); (5) Application of Process of Digestion to Everyday Nutrition Habits; (6) Feeding the School Child (six to sixteen years of age); (7) Corrective Diets; (8) Psychology of Adolescence; (9) Caloric Value of Foods; (10) Menu Planning.

There has been but one Nutrition Specialist in the Department. Beginning with November, Miss Adele Koch has come to the Department as Home Economics Specialist. In such capacity she is assisting with the nutrition program taking care of the calls which the Nutrition specialist cannot include in her program.

This year there has been created a research nutrition division in the resident Home of Economics Department. Dr. Marie Dye from the University of Chicago is the instructor in charge. We hope to get valuable illustrative material for special features of the nutrition program this coming year through this department. All nutrition publications having been published since the beginning of the school year have been referred to Dr. Dye for consultation. This is a custom which will be definitely followed in the future. The nutrition material since September has been the school nutrition series which was carried on last year and is being carried on this year with some variations.

The chief problems in nutrition work in the state may be shown from the following analysis of Michigan's Nutrition Project:

ANALYSIS OF NUTRITION PROJECT

GROUP I

Nutrition Habits:

Bread and coffee families—so called because above forms nucleus of family diet. Scanty supplies of milk; little or no vegetables other than potatoes; and little or no fruit.

Outstanding Diet Habits:

Not enough calcium and iron. Inadequate protein. Not enough vitamins. Too much highly seasoned foods. Too high a proportion of carbohydrates. Not enough bulk. Faulty food habits.

Deficiencies—Supplies:

Not enough vegetables, not enough milk, not enough fruit.

Resulting Health Conditions:

Malnutrition in children. Defective prenatal feeding. Rickets. Infantile scurvy. Early aging. Increased susceptibility to disease. Defective teeth. Tuberculosis. Constipation. Anemia. Tendency toward diabetes.

Remedies:

More mineral foods; a, milk, b, vegetables, c, eggs, d, fruit, more vitamin foods; a, milk, b, butter, c, spinach or greens or tomatoes or fruit, d, whole grain cereals. More protein foods; a, milk, b, eggs, c, meat in moderation.

Suggested Changes in Conditions:

Increased consumption of milk. Increased consumption of vegetables. Increased consumption of fruit. Milk in place of coffee for children. Teach American preparation of foods. Encourage vegetable and fruit production. Better food habits encouraged, regularity of meals, eat at regular intervals and not between meals, unhurried meals, happy meals.

GROUP II.

Nutrition Habits:

Bread, meat, potato, coffee, sweet family, very little milk, little or no vegetables other than potatoes.

Outstanding Diet Habits:

Not enough calcium and iron. Insufficient vitamins. Too much fried and highly seasoned foods. Not enough bulk. Faulty food habits. Not enough necessary growth habits.

Deficiencies—Supplies:

Not enough vegetables. Not enough milk. Not enough fruit.

Resulting Health Conditions:

Malnutrition in children. Defective prenatal feeding. Rickets. Defective teeth. Capacity for work hampered in adults. Constipation—tendency toward nephritis if too much meat. Chronic condition of toxic nature.

Remedies:

More mineral foods: a, milk, b, vegetables, c, eggs, d, fruit. More vitamin foods, no fried foods for children particularly. No tea or coffee, for children. Regularity of meals. No eating between meals.

Suggested Changes in Conditions:

Increased milk consumption. Increased vegetable consumption. Increased fruit consumption. Teach preparation of foods other than frying. Encourage moderation in meat. Discourage coffee and tea for children. Encourage vegetable and fruit production and preservation budget. Better food habit, regularity of meals (eat at regular intervals and not between meals.)

GROUP III

Family whose diet is fairly liberal, but does not realize the importance of milk and vegetables besides potatoes every day.

Irregular or faulty food habits. Too many fried or highly seasoned foods. Not enough calcium and iron.

Not enough milk. Not enough vegetables. Not enough fruit.

Children not resistant to diseases. Many children undernourished. Deficiency in diet of prospective mother. Defective teeth. Constipation—not full capacity for work. Chronic condition of toxic nature.

Absolute every-day regularity in consumption of: a, milk, b, vegetables. No fried foods for children. No tea or coffee for children.

Increased every day consumption of milk. Simpler foods at social functions. Regularity of meals established. Increased fruit consumption. Teach menu planning. No coffee or tea for children.

The ultimate state goals are: One, active enthusiasm of communities over entire state for the work; (2) through this enthusiasm a home demonstration agent established in every county; (3) requests for organized types of work; (4) development of local leadership; (5) spread of influence in community.

The state goals for the year are: (1) number of people with increased interest in food and nutrition; (2) increased consumption of milk, vegetables, and fruit; (3) increased number of family vegetable gardens; (4) increased vegetable, fruit and meat canning; (5) less fried foods and coffee; (6) number of people practicing improved food habits; (7) number of definite demonstrations established in prenatal feeding, baby feeding, pre-school child feeding, school child feeding, overweight, underweight, constipation; (8) definite local leaders in each community where nutrition course has been given.

In the work with women the present plan of working with a group for a series of meetings is proving very successful. Women are interested and the Specialist finds them returning to the meetings having actually changed food habits for the better. In the three instances where real training classes for local leaders have been held, they have proven very successful. No greater responsibility has been placed upon the individual local leader than to request that she report the meetings to her local organization, that she distribute the bulletins on child feeding when they can be used, that she get definite mothers to agree to check the cards on pre-school and school child feeding for one month.

The chief difficulty with carrying on work through training classes for local leaders has been that it requires a great deal of individual work to get the plan underway. In each instance the work has been handled through the home demonstration agent. Where there is no demonstration agent it has thus far seemed impossible to organize the work.

In connection with the nutrition work the Specialist has been carrying on a school nutrition series. This plan has made use of the teacher as a local leader. One nutrition story with accompanying illustration material is being sent each month to the schools enrolled. This year's series runs as follows: (1) Good Growth Story; (2) Milk Story; (3) Vegetable Story; (4) Potato Story; (5) Fruit Story; (6) Good Breakfast Story; (7) Rest Story.

The county agents have acted as county chairman for the work. In the present plan they have been responsible for placing the work in definite communities in their respective counties. In many instances their interests has been active enough to provide transportation to and from place of meeting, etc. They have handled all publicity for the meetings. In the school nutrition series, with co-operation of the county school commissioner, the county agent has been a very active factor in getting the series underway.

In the nutrition program the home demonstration agents have been very effective local leaders. The Specialist has found that one visit to an organized county has resulted in enough suggestive material to the home demonstration agent to supply her with material for several months. The home demonstration agents have made quite active use of the bulletins on child feeding. More than half the copies of the school nutrition series go to home demonstration agents for distribution.

The Boys' and Girls' Club Leaders have been active in helping with the nutrition meetings held under the supervision of the Specialist in their respective counties. They have acted as local leaders in that the Specialist has met with them two definite times during the year and discussed Michigan nutrition problems. They have helped in introducing the school nutrition series in their respective counties.

The Specialist has given in all 105 lectures to club organizations with a total attendance of 7,732; and 34 lectures at community meetings with a total attendance of 995. While there has been no definite means of tabulating results from return visits, letters, etc., the Department knows that many suggestions were adopted. There were forty lectures given school children with a total attendance of 2,396.

During the winter of 1921-1922, a consecutive series of nine lectures were held in Barry county. There was no method devised of definitely tabulating results of those meetings. Training classes for local leaders have been conducted in Menominee county, Kalamazoo county and Wayne county. Such meetings number in all thirteen, with a total attendance of 386. In Menominee county the effort was simply that of having the women return to their respective communities giving a report of the meeting. This was done. In the Kalamazoo county meetings, pre-school child home cards and school child home cards were distributed and each local leader agreed to make a consistent effort to establish home demonstrations through them. Time has not yet elapsed to get the data from these demonstrations.

Reports for the school year 1921-22 of the school nutrition series is as follows:

The School Nutrition Series has reached in part or in whole, 44 counties, 1,941 schools and 44,643 children. Since the Series has been introduced during the entire school year, it has been impossible to complete it in every instance. The results stand as follows:

Children having formed daily milk drinking habit for one month	52%
Children having formed daily big breakfast habit for one month	81%
Children having formed daily habit of eating vegetables other than potatoes for one month	59%
Children having formed daily habit of sleeping at least ten hours for one month	46%
Children having formed daily habit of not eating knick-knacks between meals	36%
Children having formed daily habit of brushing teeth before going to bed	41%
Children having formed daily habit of eating a good serving of fruit	43%
Children having formed daily habit of eating a big breakfast, big dinner, big supper	44%

REPORT OF JUNIOR EXTENSION WORK BOYS' AND GIRLS' CLUBS.

BY R. A. TURNER.

The activities of the Junior Extension staff are reported upon under the project headings given below:

- Home Economics Clubs:
  - Canning
  - Cooking
  - Hot lunch
  - Clothing
  - Own your own room
- Agricultural Clubs:
  - Pig
  - Calf (Dairy and Beef)
  - Sheep
  - Corn
  - Bean
  - Potato
  - Poultry
  - Handicraft
  - Garden

HOME ECONOMICS CLUB WORK FOR 1922.

The enrollments in Home Economics line of work continued to exceed those of 1921 by 25.6 per cent. For the first time in three years we have been able to have a consistent summer program develop in the upper peninsula. Last February we secured the services of Miss Ruth Cresswell, formerly in charge of girls' clubs in the state of Washington, for assistant state club leader, having charge of the upper section of Michigan. She has done a very splendid piece of work. In order to enable us to carry out in the lower peninsula our full summer program, which this year included several camps, we secured the help of Miss Nathalie Vasold, formerly on our staff, for a period of six weeks. This made it possible also to develop the girls' standards of the Club Tour held at the College in August for the stock judging elimination contest. Every two days a new group, representing five to seven counties, came in, and girls having completed the winter project or actively engaged in the summer work being eligible to attend. For this short period instructions in Home Economics were given, resembling to a certain extent, the large program during state club champions' week. A total of about fifty girls attended this year. We expect next year this number will expand to about one hundred.

For 1923 we are assured of exhibit space at the State Fair so that all Home Economics work will be represented. The demonstrations will be held on a competitive plan, the team winning first place in each line of work, winning a trip to Club Champions' Week at the College where they will put on a demonstration for the girls assembled here at that time.

CANNING.

Although the statistical report for canning club work shows only a 25 per cent increase over last year's figures, we feel that a definite progress has been made. We have had more second, third, and fourth year girls enrolled this year than ever before and almost invariably these girls have canned much more than the required amounts. Our goal for the clubs this summer was "Enough for the Family," based on the canning budget which was sent out at the beginning of the season.

The canning project is divided into four years of work, the fourth year girls taking the leadership of a group of younger girls if possible. During the past year, many of the girls did this and were very successful with their clubs. A revised edition of our old canning bulletin was printed early in the summer.

This spring we devised a home-made steamer, for the purpose of economy of heat and time in processing fruits and tomatoes. This was approved by the M. A. C. Bacteriological Department and has been successfully used by the girls this summer. It has been very convenient for the purpose of demonstration as well.

Our demonstration teams were composed of only two members this year which we found worked much better than the three-girl teams. Fourteen teams demonstrated at the State Fair. These teams were chosen from clubs which had done especially good work during the summer. Jelly-making seemed to be the most interesting demonstration, judging by the attitude of the Fair crowds, although the use of tin cans and the demonstration in meat and soup canning attracted many people. The team from Coldwater, Branch county, was chosen at this time to represent Michigan at the Sioux City Contest. The Coldwater Board of Commerce paid the expenses of the girls for this trip. Although this is the first year Michigan has entered this contest, we hope it may now be an annual affair. Seven of our canning club girls attended the International Live Stock Show, three receiving the trip as awards from the Hazel Atlas Glass Jar Company and the other four being sent by their respective counties for their splendid canning records.

There were four cities—Bay City, Grand Rapids, Detroit and Bloomfield Hills Community—which carried on club work through canning centers at the public schools. Much of this work was done in connection with the city garden clubs. Many of the mothers were reached through these centers and in Detroit they were opened on certain days for the foreign mothers to learn more about the cold pack method.

Leadership is more difficult to secure for canning clubs than for winter clubs. Housewives are very busy at this time and teachers are usually not available for the entire season.

Canning seems to run second to garment-making in popularity. This was true for the first year clubs were organized in Michigan and seems to be continuing. Since the drop after the high peak of 1918, the average yearly increase in number of clubs has been between 25 and 30 per cent. Although this is not a high figure, the growth is substantial and the project is retaining interest of the girls who start it, so that we feel it is holding its own.

COOKING.

This past summer we have had enrolled only twelve cooking clubs. We have not pushed this project especially hard because we felt that it has still been in the experimental stage and it would be better to wait until we were a little more sure of our project before organizing it too extensively. It is very hard to obtain competent leaders—leaders who can teach food values and basic principles of cookery rather than recipes. We have decided that the method we have used heretofore in presenting our cooking lessons must be changed and more detailed instruction given so that leaders who have had no definite training along this line may still handle the project.

This is the first summer we have tried out the third year's work. This consists of meat cookery and bread making and the girls were very much interested in it, more so than in the first or second year's work, we believe. One club gave a demonstration on bread making at the State Fair which attracted much attention.

The second and third year girls exhibited some of their baking in the open class at the fair, competing with the women and receiving many prizes.

We hope to put this project on a little better working basis next year and to be able to organize and carry on the work with a greater number of clubs.

HOT LUNCH.

Hot Lunch Club Work began in Michigan in 1918, with one club. Since then its organization has grown as follows:

	1919	1920	1921	1922
Clubs	18	78	134	170
Enrollments	563	1,807	2,577	3,289
Servings	40,021	140,364	198,170	316,502

The increase, 26.6 percent between 1921 and 1922 was not nearly so great relatively as between the earlier years, but the number of servings has increased nearly 100 per cent, which shows longer seasons of serving, even though last winter was a mild one. We have decided after some investigation that the small per cent of increase is not due to lack of interest, for about one hundred requests came in for bulletins not followed by club enrollments, but due to the fact that the hot lunch system appears too complicated, particularly in its accounting. For this reason an estimate has been made of the cost of each product used in the recipes and the cost of serving of each recipe in the bulletin. This, together with a simpler accounting system, as shown on the attached sheet, has been received with a great deal of relief by both county and local leaders and this year we look for better results in the number of hot lunch clubs enrolled. If we were to write an entirely new bulletin, we would recommend other changes in the organization of the work, but this will not be done until the present supply is exhausted in order to present too much confusion of ideas.

Several schools observed so far in the 1922-1923 season have added considerably to their equipment indicating the security of the project where it has once been successfuly carried out.

Very strong support is coming to us from the county nurses. For a few years we found it difficult to get them to organize the groups into clubs, though they did promote the serving of a hot food at noon. This year a large number of the county health workers are co-operating with us, realizing that permanency of the work in a school cannot be secured when there is a rapid change of teachers and no well-organized group left behind to start the new and perhaps uninterested leader. The influence of the nurses is the strongest factor we can call to our assistance, and we look for good results from this co-operation.

CLOTHING.

The garment work still leads the Home Economics subject in popularity, due to several reasons. First, the immediate utility of the product, second, the season of the year in which the work is done (winter), and third, the fact that it is the easiest project for which to find leadership. There is also a more pronounced sentiment on the part of high school superintendents to credit the sewing work done by farm girls preceding their entrance to the high school. In many instances their departments at the high schools are especially crowded in the ninth grade, so several have met this situation by allowing ninth grade credit to girls who have completed the first two years of garment club work. An especially encouraging support from educational sources comes from the Western State Normal. Their registrar has found that he cannot admit to its Home Economics course because of crowded conditions, girls who have not had previous work in this line. They now accept club certificates of achievement given in the first two years of garment work as the necessary prerequisite for their courses.

Three years ago we attempted to restrict our garment-making to winter season only, realizing that unless we did so, we could no longer give satisfactory help on the project to our county and local leaders, owing to the pressure of the canning and fair seasons. There was some opposition at first, but with this as a second summer, we had but five summer garment clubs, where before almost one-half of them were working through the summer. This has worked to great advantage in keeping up our canning enrollments, and we would not change back to the old system unless forced to do so.

The work runs through three years as follows:

First Year.

Bag or sewing apron (hand).
Kimono draft and one garment (machine).
Bloomers or second garment on draft (machine).

Darn 2 pairs stockings.
1 overhand patch.
1 hemmed patch.
Report and story.

Second Year.

Bloomers.
Princess slip.
Corset cover or camisole.
Envelope.
Underskirt.
Kimono.
Dress.
Skirt.
Middy Blouse.
Smock.
Club uniform (middy suit).
One-piece dress with set in sleeves.
Jumper suit.
Child's suit.
Report and story.

Third Year.

Budget.
Remodeling of woolen dress or making a new woolen skirt with suitable blouse.
 (textile study.
 (stain removing.
 (dyeing.
Notebook.
 (cleaning and pressing.
 (color.
 (design.
 (report and story.

After the third year, girls may elect the Household Management and Interior Decoration project or help lead a garment club.

In all our projects we find this to be true—those who drop out do so almost always during the first year. Those completing the first year usually elect the second. Owing to separation of the groups for various high schools at this time, there is a decided drop between the second and third year enrollments. However, third year girls enrolled finish nearly 100%, and last year nearly all elected the Home Management work. 97% finished. The following is the record since the war peak:

	1918	1919	1922
No. clubs	215	159	331
No. enrolled	2,527	1,981	3,214
% of finishers	42.06%	41.8%	72.68%

For the first three years we have been experimenting on the requirements for this work until we are satisfied that the present suggestions are practical. Our new bulletin has been promised by the printer for delivery January 1st.

OWN YOUR OWN ROOM

(HOUSEHOLD MANAGEMENT AND INTERIOR DECORATION)

This is the second year of this project as a piece of work separate from the garment making. This is the record for the two years:

	1921	1922
No. Clubs	3	13
Enrollment	23	65
Value	$62.00	$714.25

Last year the beginning was made for running the "testing circle" work for home conveniences. Four articles were tried, dish drainer, oiled dust cloth, bread mixer, fireless cooker, besides some small kitchen utensils, such as spatula, kitchen scissors, etc. This year we plan to introduce rearrangement of kitchen furniture, making it a problem in household engineering. The Women's Extension Specialist, Miss Rogers, will co-operate with us working this up.

The amount of work done by the girls last year exceeded by far that of 1921. Only one small club of four girls made the inside limit of three articles, many of them making as high as eight. One girl repapered nearly the entire house, refinished floors and woodwork in several rooms, and altered her own furniture.

It is not hard to interest leaders in this work. Practically all of them were garment club leaders and, therefore, experienced. However, they unanimously agree that this is the year affording the greatest pleasure to the girls and themselves, and is a project where it is really necessary to exercise a little restraint rather than to urge the girls on. We are looking forward to the development of this work with a good deal of interest, for the exhibit during club week fascinated the champions who saw it, and this precludes good clubs.

LIVESTOCK

Under this phase of the Boys' and Girls' Club Work, I will discuss briefly the pig, calf—both dairy and beef, and sheep club projects.

1. Organization.

We encourage the year around club in all of the livestock projects. While the members are required to keep records only a part of the time —4 to 6 months—meetings are held throughout the year, thereby keeping alive the club spirit. As far as possible, the calf and sheep clubs are organized in the late fall and early winter, while the pig clubs are organized in the spring. It is our plan to have the records start so that the required time will be completed by the time the local or county fair is held in the fall.

In this state, many breeding associations are being built around the Boys' and Girls' Live Stock Clubs. Two methods are used in forming these associations; viz: 1-A parent, local leader, or other interested person who buys the club sire outright and charges each member so much for service, or, 2 The club as a whole buys a good club sire. In either case the sire may be used by persons living in the community upon payment of a nominal service fee.

In one of our counties (Eaton) there are ten such associations consisting of a total of 128 pig club members. A number of these associations were started two years ago and have operated very successfully since. In buying the boars, the county agent, Mr. R. W. Tenny, has been very careful to buy animals that might be interchanged between clubs at the end of one year. This makes the period of use for a good sire for at least three years where there are three clubs in the breeding circuit. Mr. Tenny is building his live stock improvement program around the Boys' and Girls' Live Stock Clubs.

Before live stock clubs are organized in a community or county, an attempt is made to hold a meeting of all the breeders of that class of live stock. At this meeting an outline is given of club work, co-operation expected of breeders and followup work to be expected from the county and state club offices. Our most *permanent clubs* are built around the live stock breeders.

2. Supervisory Program.

The assistant state club leader in charge of live stock club work assists county leaders in outlining their plans of work for the year, meets with county breed associations, and goes into the county at least once while the project is being conducted to give assistance in subject matter instruction. In addition he helps to plan club tours, has charge of the district live stock contests and the live stock exhibits and contests at the State Fair, and also assists in closing up the club work at county fairs in the fall and achievement days. More details of the club tours and how the supervisory program is carried out, will be given under the heading "Project activities and results."

Subject Matter Assistance: Standard publications such as state and U. S. D. A. bulletins appropriate for the different projects are listed by the Boys' and Girls' Clubs Department. These lists and the necessary bulletins are sent to the different county leaders. The bulletins are supplemented by timely seasonal suggestions on the various projects. All subject matter is written up in co-operation with and by the hand of the proper department of the college.

At the beginning of the year my plan is to look over the different county club agents and county agents programs of work for the year and from these learn the most pressing livestock problems. As far as possible, the subject matter we send out fits in with the "attack" of these problems.

3. Project Activities and Results.

I find that one of the most effective ways of reaching the 39 counties with 1529 boys and girls that are doing live stock club work is through club tours and district stock judging "meets." In this way I can reach the largest number of members in a given period with the "follow-up" work. These tours start June 15 when the organization period closes and close August 15 when the district contests begin.

One to two-day tours were held in 25 counties. To make these attractive as well as instructive the object of the tour was given as practice stock judging, the ultimate object being to select the county group that would go to the district judging contest where the county live stock teams for the State Fair were to be selected. Many parents as well as breeders attended these tours.

A typical two-day tour would be something like this. All live stock club members, breeders, and parents assembled at some farm where a good class of animals could be obtained. I would discuss one animal and then let the club members make a placing on a class and give their reasons. Then I would discuss the class. Three farms with different breeds or classes of animals were visited during the day. At noon we would have basket lunch. We tried to finish our stock judging by four o'clock. Then indoor baseball games would be played between clubs while a few members were detailed to prepare for supper. Usually we had a weenie roast at supper. Around a camp fire after supper I would give a short talk on feeding and management. Then an extemporaneous program would be put on by the club members. At 10 o'clock p. m. everyone "turned in," the boys sleeping in a barn or a tent while the girls spent the night in a near-by farm home or in tents. Breakfast and lunch on the second day were prepared and served similar to the supper of the previous day. Club members furnished their own dishes and a loaf of bread, ½ lb. of sugar, ½ lb. of bacon, 6 eggs, and 50 cents.

We took up practice judging and fitting and showing the second day.

On these county trips we selected eight club members to go to the district round-up. Three round-ups were held, one at the state agricultural college at East Lansing for all the southern counties, one at Traverse City for all counties in the northern part of the lower peninsula and one at Chatham for all counties in the upper peninsula. 333 club members from 29 counties with a total attendance of 398 participated in these "round-ups." Two days' work in feeding, stock judging, fitting and showing was given. Members of the Animal Husbandry and Dairy Husbandry Departments of the college assisted in the instruction. 19 of these counties came into the college in three different groups. They stayed over night in the dormitories.

The 19 county club Animal Husbandry and 12 county club Dairy judging teams that judged at the State Fair were selected at these round-ups. There were also selected 5 stock fitting and showing teams.

At the State Fair a dairy judging team was selected to go to the National Dairy Show at St. Paul, Minn., where they competed with 13 other state teams. Michigan had 5th high man in entire contest, was high team on Holsteins, had first and fifth individual judges on Holsteins and had 5th high individual on Jerseys.

The Fitting and Showing Team which represented Michigan at the National Dairy Show won 4th place with 14 teams competing. A Michigan boy was second high individual of the entire contest.

The Animal Husbandry judging team which was selected at the State

Fair and competed at the International Live Stock Show at Chicago won 7th place with 19 state teams competing.

I feel that the big value of our live stock judging was in the training we gave the 1500 live stock club members in the county rather than the placings of the three club teams which represented Michigan at National Shows.

Club Exhibits: 211 head of animals from 6 counties were exhibited at the State Fair by live stock club members. They won the 2nd prize carload of fat steers in the open classes with 11 cars competing. A club member won the Junior Champion Poland China Boar in the open class. The Junior Champion Berkshire sow pig in the open class was owned and shown by a club member. A large number of other placings were made in the open classes by club members.

Pig Clubs: There were 118 pig clubs organized in 34 counties with an enrollment of 1,020 members. 732 members reported showing total expenditures of $23,183.17 and receipts of $37,416.67 leaving a net profit of $14,233.50

Dairy Clubs: There were 35 dairy clubs organized in 12 counties with an enrollment of 338 members. 272 members reported showing total expenditures of $22,601.20 and receipts of $32,754.06, leaving a net profit of $10,152.86.

Beef Clubs: There were 6 clubs organized in 6 counties with an enrollment of 89. 71 members reported showing expenditures of $6,085.03 and receipts of $9,069.29, leaving a net profit of $2,984.26.

Sheep Clubs: There were 10 sheep clubs organized in 7 counties with an enrollment of 81 members, 47 members reported showing a total expenditure of $2,361.84 and receipts of $4,018.78, leaving a net profit of $1,656.94.

4. OUTLOOK.

1. I am planning to do the club work in 1923 as it has been conducted this year. The parents and live stock breeders have gotten behind the program as outlined this year in such a splendid manner that I feel we are working along the right lines.

2. The supervisory program in 1923 will be essentially the same as in 1922.

FARM CROPS

The farm crops clubs organized during the year include those in corn, bean, and potato.

Tabulation shows the following results:

Project	No. Counties	No. Clubs	Enrollment	No. Completing	Value
Corn	7	12	96	63	$3,141.70
Bean	4	5	21	18	511.80
Potato	23	39	305	231	6,257.19

That crops club members learn and demonstrate good practices is shown in the yields obtained as compared to average yields for Michigan for 1922.

Project	State Average	Av. Obtained by Club Members
Corn	34.8 bu.	76.08 bu.
Bean	10.5 "	12.5 "
Potato	104.0 "	119.0 "

During the summer some subject matter assistance in grain judging was given to corn and bean club members in the several counties having those clubs. At the Michigan State Fair, 8 judging teams from as many counties competed for state honors in a state-wide grain judging contest. The Washtenaw County team, as winners, were awarded a trip to the International Grain and Hay Show at Chicago. Several similar contests were held at county fairs, the winners being awarded a similar trip.

Michigan again exhibited corn at the National Corn Club Show and at the International Grain and Hay Show. A number of enviable winnings were made at each.

That club members can demonstrate the mixing of spray mixtures was shown in the five demonstrations at the State Fair. The team from Presque Isle County was sent to the Michigan Apple and Potato Show at Grand Rapids to repeat their demonstration.

A potato club section was provided at the Michigan Apple and Potato Show.

The annual potato club show was held at the college during Farmers' Week. At that time the state championship was determined and the loving cup provided by the Michigan Exchange awarded.

POULTRY

In co-operation with Mr. E. C. Foreman, Extension Specialist in Poultry, a program of work for this past year was outlined. The demonstration was divided in such a way that the club member was given the choice of following the line which best adapted itself to his club and his community. Hatching and brooding work included the setting of the eggs, hatching, brooding, feeding, and care of young chicks. Financial returns came from the sale of chicks raised. In many instances the best birds were retained to be used as a foundation for second year's work. In the egg and meat production work, club members started with mature birds. Financial returns were had from the sale of eggs and meat. It was noted that an increased number of poultry club members took over the care and management of the farm flock, and usually, with the most satisfactory results. In an increased number of instances, it was noted that club members had demonstrated to their community good practices in poultry keeping to such an extent that the poultry industry of that community had been revolutionized.

County, district, and state fairs co-operated in providing for Poultry Club exhibits and demonstrations. At the Michigan State Fair, the

Poultry Club program was larger than ever before. More birds and these of a better quality were exhibited. Poultry demonstrations were given throughout the period of the fair as were also the judging contests. An egg-laying contest was conducted similar to that for the adult breeder.

HANDICRAFT

Handicraft club work, as a winter project for boys, has thrived in Michigan where it originated in 1915. A gain of 75% in the number of clubs organized over the preceding year would seem to indicate that the project is answering a real demand for this type of club work.

During the year the Club Bulletin No. 11 "Handicraft Club Work" has been revised and printed.

Handicraft club members have made a very definite contribution to extension work in the making of large numbers of farm and household conveniences, this being especially true in the case of the latter. Home demonstration agents have found that handicraft club work is a valuable assistant to their programs for household management.

Additional publicity was had through the many demonstrations given at community, county, and state fairs. These demonstrations should tend to further increase the scope of the project during the coming year.

An exhibit of handicraft club work was sent to the Interstate Fair at Sioux City, Iowa, and also at the First International Boys' and Girls' Club Exposition at Chicago.

GARDEN

Garden Club Work has again proved to be most popular in the cities and larger towns and villages. In several cities it still continues since it was first established during the war period.

This year's results show that the big majority of garden club members raised garden products for home use. Only a comparatively small number were on a commercial basis, but these succeeded in their business through the medium of curb markets or by selling their products to summer resorts.

Detroit, Grand Rapids, and Bay City were outstanding in the amount and quality of garden work done. Co-operating with the college were the Recreation Commission, the Board of Education, and the Civic League, respectively, in the above named cities.

C. Kind and quality of leadership.

The following table shows the occupations of local club leaders, Michigan, 1922:

Project	Farmers and Breeders	Housewives	Teachers	Carpenters	Students	Florists	Ministers	Miscellaneous
Clothing	....	80	265	....	....	....	....	....
Handicraft	40	2	108	21	....	....	2	4
Hot Lunch	....	26	170	....	....	....	....	....
Cooking	....	12	....	....	....	....	....	....
Canning	....	63	29	....	10	....	....	31
Corn	12	....	....	....	....	....	....	....
Bean	5	....	....	....	....	....	....	....
Potato	30	....	9	....	....	....	....	....
Pig	86	3	4	....	2	....	4	19
Calf	37	....	....	....	4	....	....	....
Sheep	9	....	....	....	....	....	....	1
Poultry	21	20	15	....	2	2	2	4
Garden	5	17	30	....	4	6	....	207
Totals	245	223	630	21	22	8	8	266

D. Results in terms of demonstrations or projects.

Project	No. of Clubs	Enrollment	No. Reporting	Value
Corn	12	96	63	$3,141.70
Potato	39	305	231	6,257.19
Garden	193	5,484	2,695	21,987.40
Pig	92	781	593	21,331.44
Sow and Litter	26	239	139	16,085.23
Dairy Calf	29	268	211	18,296.95
Dairy Heifer	4	50	45	10,260.00
Cow and Calf	2	20	16	4,197.11
Beef	6	89	71	9,069.29
Sheep	10	81	47	4,018.78
Poultry	67	489	264	11,230.24
Canning	133	1,828	1,171	35,590.86
Meal Preparation (Cooking)	12	71	53	542.18
Hot Lunch	170	3,289	2,555	5,994.50
Clothing	332	3,214	2,336	12,512.62
Own Your Own Room	13	65	63	714.25
Bean	5	21	18	511.80
Handicraft	175	1,667	966	5,569.90
Totals	1,320	18,056	11,537	$187,311.44

EXHIBITS, CLUB ENCAMPMENTS, ACHIEVEMENT PROGRAMS

201 state and county club champions and leaders enrolled for the Fourth Annual Club Week at M. A. C., July 10-14, 1922. Through arrangements with the State Board of Agriculture, these champions were housed in the college dormitories. During the week they were not only given instruction in good practice in agriculture and home economics, but they were brought in close touch with the college and its various departments. 24 of those attending held scholarships at M. A. C. and expect to enter this college.

174 club members from the upper peninsula attended the Third Annual Club Camp at the college experiment station at Chatham, August 5-9, 1922. Instruction in cookery, sewing, poultry, stock judging, potato disease control, etc., was given. The college, through the officials at

the station, co-operated in supplying camping facilities, live stock as awards in the judging contest, etc.

In several counties, club camps were held for the club members in those counties. Members of the state staff assisted with most of these.

The Sixth Annual County Normal Day brought several hundred Normal students to M. A. C. on May 11 and 12, 1922, when the college acted as hosts through the club department. Since the students in the County Normals are to teach in rural schools and should be somewhat familiar with the agricultural college, this means is taken to supply that need.

Some 300 club members were at the State Fair at Detroit, Sept. 1-10, 1922, as exhibitors, members of judging or demonstration teams. A club camp was maintained through arrangements with the state fair officials. The State Club Leader is superintendent of the Boys' and Girls' Club Department of the Fair.

County Achievements Days have been held in the several counties to bring to a formal close the work of the season or year. That these achievement days have a stimulating effect upon the work of the following season is not questioned.

61 club champions and winners of trips made up the Michigan delegation to the International Live Stock Show at Chicago. 86 are eligible to attend the 1922 show. This trip has a far reaching value in promoting a constructive interest in club work throughout the state.

Report of the Extension Work in Farm Crops.

Summary by Prof. J. F. Cox.
Introduction of Varieties by G. W. Putnam.
Crop Improvement by Howard Rather.
Varietal Demonstrations by D. F. Rainey.

Summary.

The demand for Extension work has increased to the extent that it is not possible to meet all requests for service with the staff available. The careful development of leading projects has, we believe, led towards greater efficiency in work performed.

Mr. G. W. Putnam was placed in charge of the general crops Extension projects April 1st, being transferred from the position of Crops Experimenter, assigned to the Upper Peninsula. The alfalfa and legume campaigns, begun last fall, have occupied a large part of his time. Mr. Putnam is also in charge of the direction of the field inspection work of the Michigan Crop Improvement Association, and the release of new varieties from the college increase plats.

With the resignation of Mr. A. L. Bibbins, January 1st, 1922, to become Manager of the Seed Department of the Grand League Federation Exchange of Syracuse, New York, Mr. H. C. Rather was elected Secretary of the Michigan Crop Improvement Association and placed in charge of the crops varietal standardization project. Close co-operation with the Farm Bureau Seed Department has greatly increased the influence of the Crop Improvement Association.

Crop demonstrations and varietal test, handled by Mr. D. F. Rainey, have proved to be of great value in aiding in the dissemination of crop varieties according to adaptations. In many counties the alfalfa campaign work is made particularly effective due to the presence of carefully planned alfalfa demonstrations planted one or two years before.

The demand for crop exhibits at County Fairs, the State Fair and the International Grain and Hay Show, required considerable preparation along that line. Mr. H. C. Rather, assisted by members of the Farm Crops Department, handled this work.

With the assignment of the potato crop to this department, Extension work in the standardization of potato varieties, spraying, and cultural demonstrations has been undertaken. A report of the Extension work with potatoes has been submitted. Details can be found in the reports by Mr. J. W. Weston and Mr. H. C. Moore, Extension Specialists, assigned to potatoes.

At a September meeting of the State Board of Agriculture, Mr. Moore and Mr. Weston were each made quarter-time assistants in experimental work.

The daily correspondence relating to field crops has steadily increased, averaging a total of 68 letters per day.

ALFALFA AND LEGUME CAMPAIGN

Owing to the success which alfalfa growers have met with during recent years, and from the standpoint of permanent soil benefit, and the livestock situation in Michigan, it was deemed advisable to greatly increase the acreage of alfalfa. In most localities alfalfa is a "key crop". Not only is the growing of this crop directly profitable, but the indirect benefits are very great. The successful production of alfalfa necessitates liming, the use of phosphate, etc., and leaves the land in excellent condition for growing general crops. It is also of great value in cheapening and bettering livestock feeding rations.

A state-wide alfalfa campaign was announced in August, 1921. The work was placed on a county basis being conducted either in co-operation with the Dairy Department, as a "dairy and alfalfa" campaign or as a straight "legume" campaign. The "dairy" and "alfalfa" campaign beginning October 29th to November 5th, held in Allegan county, was led by two teams, each composed of one man from the Farm Crops Department and one from the Dairy Department, each making four meetings per day with one night meeting. The meetings were held in barns during the day-time and in Grange Halls and other campaign meetings places at night. Over two thousand, four hundred farmers attended these meetings and it was estimated that the alfalfa acreage in Allegan County had increased to three thousand acres—over 70% during the past spring.

Alfalfa "Campaigns" were conducted in fourteen counties, though practically all County Agents extended the alfalfa and legume acreage as a main project.

Mr. V. H. Church, Crops Statistician of the United States Department of Agriculture, states that the alfalfa acreage of Michigan has increased from 76,000 acres in 1919 to 348,000 acres cut for hay in 1922, with a total of one-half million acres including new seeding.

Most of the farmers estimate that the successful growing of alfalfa on land will increase its value from twenty to forty per cent. Allowing an incrcease of $10 per acre in land valuation, it is not unreasonable to believe that the increased plantings of alfalfa will benefit the state by at least $2,000,000 due to the added land valuation. There is a great increase in hay yield equal to at least one ton of extra hay per acre above clover and clover and timothy worth from $10 to $15 per ton, or an additional two million dollar or more.

The chief direct benefits from alfalfa are additional profit from the crop and more economical feeding of livestock. It is reasonable to believe that an increase of over two hundred thousand acres, placing the alfalfa acreage of Michigan over five hundred thousand acres, will result within a year in added returns of from four to eight million dollars, with increasing future returns due to more livestock carried per farm, increased milk production and increased yields of the crops following alfalfa. The establishment of a successful stand of alfalfa pays not only immediate profits, but substantial dividends distributed over many years.

Proper methods of establishing successful stands of clover, red clover, alsike, mammoth and the value of other legumes, such as vetch and soybeans, were emphasized in regions where these crops are needed and adapted. Legume campaigns will be conducted during the coming year in the potato, bean, sugar beet, canning crop producing counties and livestock counties. All members of the Farm Crops Department, in addition to the regular Extension men, are aiding in the alfalfa work.

The immediate success of alfalfa and better clover campaigns was made possible, largely due to the excellent seed supplied in quantity from dependable sources by the Farm Bureau Seed Department. Over two hundred and eighty thousand pounds of Grimm alfalfa seed and approximately three hundred thousand pounds of northern grown common was distributed in Michigan in 1922 by the Farm Bureau. Home grown alfalfa seed played an important part in increasing the acreage in many counties under favorable seed producing conditions of last year. Over 200,000 pounds of Michigan grown alfalfa seed (Crop of 1921) was used in Michigan, the first time that home grown seed was of importance. The crop harvested in Monroe County alone in the fall of 1922 is estimated at 540,000 pounds, 200,000 pounds being handled by the Farm Bureau Seed Department. The production and use of Michigan grown alfalfa seed is being encouraged, particularly the Hardigan developed at M. A. C. and the LeBeau, a variety of 35 year history in Monroe County.

Crop Improvement by H. C. Rather.

The work of crop improvement in Michigan is carried on in close co-operation with the Michigan Crop Improvement Association, the Seed Department of the Michigan State Farm Bureau and County Agricultural Agents and their supporting organizations. During the past year there have been held demonstrations in seed production, selection and improvement with 392 farmers. Along with these demonstrations there has been given information concerning cultural practices, treatment for disease, and various other matters relating to crop production which make for greater efficiency and economy in this phase of agriculture.

Two hundred and thirteen of these co-operators successfully met the pedigreed seed requirements of the Michigan Crop Improvement Assn. and thereby made available 12,000 bushels of Rosen Rye, 5,000 bushels of wheat, 25,000 bushels of oats, 2,500 bushels of barley, 7,000 bushels of beans, 1,000 bushels of soybeans, and 2,500 bushels of corn, grown from improved varieties developed or approved by the Michigan Agricultural College. Practically all of the wheat and rye thus produced was sold for seed purposes either by these growers individually or from a pool which they consigned to the Seed Department of the Michigan State Farm Bureau. Similar arrangements are now under way for the disposal of the spring certified seeds insuring the widest dissemination of such quality seed throughout the entire state. In addition thousands of bushels of seed, of these varieties but a generation or so removed from certified stock, were planted and are exerting a potent influence for more profitable crop production.

A mailing list of 700 including farmers, county agricultural agents, elevators and seed houses, received from this department during the year, seven newsletters, ten printed circulars along with other matter relative to seed improvement. The circulars have a wide dissemination other than the regular mailing list and 5,000 copies of each were sent out.

A comprehensive exhibit on alfalfa was made at the Michigan State fair at Detroit and the Western Michigan Fair at Grand Rapids, and in addition detailed information on preparation of seed samples for grain shows and for the market was furnished to 500 growers, over 100 of whom made entries at the Michigan State Fair.

An exhibit extending over 58 feet of wall space and showing the work under way in Michigan for the purpose of lowering costs of crop production was prepared and shown at the International Grain and Hay Show at Chicago, December 2nd to 9th. Emphasis in this exhibit was placed on the use of legumes, particularly alfalfa, and the use of more productive seed as a means of cheapening production of crops and livestock.

Largely through publicity and work from this office, over 200 entries at the International were winning the majority of the prizes in their classes. The quality of Michigan seeds thus received international recognition with the resultant widening of the market for Michigan seed growers.

Introduction of Varieties by G. W. Putnam.

The proper release of new varieties developed at the Michigan Experiment Station is an important step in the program for varietal improvement. There has been distributed seven hundred pounds of Elite stock seed of Improved Robust beans to twenty-nine growers for increase and trial. Twenty-one bushels of Elite stock seed of Duncan corn has been released to twenty-one growers; eleven bushels of M. A. C. Yellow Dent to twelve growers; eleven bushels of Golden Glow to twelve growers; and in addition several bushels of these three varieties of corn were released through the Michigan State Farm Bureau Seed Department. Twenty pounds of the new Hardigan alfalfa was distributed to twenty-six growers. Forty-seven bushels of the new Berkley Rock wheat was released to twenty growers for increase and trial. Six bushels of the new Michigan No. 1 wheat was released to two growers for increase.

In the release of this Elite stock seed of these various varieties careful arrangements have been made to have it inspected to maintain its identity.

In taking over the work of inspection for the Crop Improvement Association a new system has been put into practice which follows the suggestions of the International Crop Improvement Association as reported at their third annual meeting at Chicago.

The new system recognizes three classes of seed: Elite, Registered and Certified. The Elite and Registered will be the source of seed for seed production while the Certified will be the source of seed for crop production. By this system the farmers of Michigan are given a source of seed of superior quality and at a reasonable price.

Applications for inspection on 393 farms have been received this year for Pedigreed seed, distributed as follows:

Crop	No. of Farms
Rosen Rye	72
Red Rock Wheat	21
American Banner Wheat	9
Wolverine Oats	63
Worthy Oats	20
College Wonder Oats	11
College Success Oats	3
Iowa 103 Oats	3
Wisconsin Pedigree Barley	13
Black Barbless Barley	11
Winter Barley	3
Soybeans	11
Robust Beans	60
Elite Robust Beans	21
Hardigan Alfalfa	19
Hubam Clover	11
Bickett Corn	13
Silver King Corn	2
Duncan Corn	6
Golden Glow Corn	10
M. A. C. Yellow Dent Corn	11

Crop Varietal Demonstration by D. F. Rainey.

Usually only one variety demonstration of any crop is placed in a county. Perhaps of greatest importance is the establishment of alfalfa variety demonstrations of which thirteen have been planted this year and five in previous years. These serve a double purpose; first, showing the value of the variegated varieties over common strains, and second, the methods of obtaining successful strains of alfalfa. Beginning next year we hope to obtain data on the yields of these different varieties.

To aid the farmers of Michigan to determine what place Hubam clover may occupy in our farming practices, 375 pounds of Hubam was distributed in 15 pound lots. Usually an equal amount of Biennial White Blossom sweet clover was also sent so that the growth of the two clovers could be compared when growing under similar conditions.

Eight counties have soybean variety demonstrations containing seven leading varieties, planted this year, the object of such demonstrations being to determine the highest forage yielding variety for different sections. Many farmers are unfamiliar with the different varieties and their habit of growth and these demonstrations furnish them with an opportunity to see some of the varieties growing side by side. Many Mammoth Yellow Soybeans are being sold yet they are one of the lowest yielding varieties in Michigan.

The Robust field bean, which has consistently proved to be the highest yielding variety at the Experiment Station, was used as a check in the three counties which conducted field bean variety demonstrations. The Robust again proved to be the highest yielding including those strains grown locally.

Two oat and two barley varietal demonstrations were planted and and harvested this year. These demonstrations included the best varieties developed by the College as well as those grown locally.

Five wheat varietal demonstrations were harvested this year and three more were planted this fall, one in each of the following counties: St. Clair, Shiawassee, and Monroe. These demonstrations include some of the best known wheats in Michigan and Ohio, as well as local varieties and new ones recently developed by the Experiment Station.

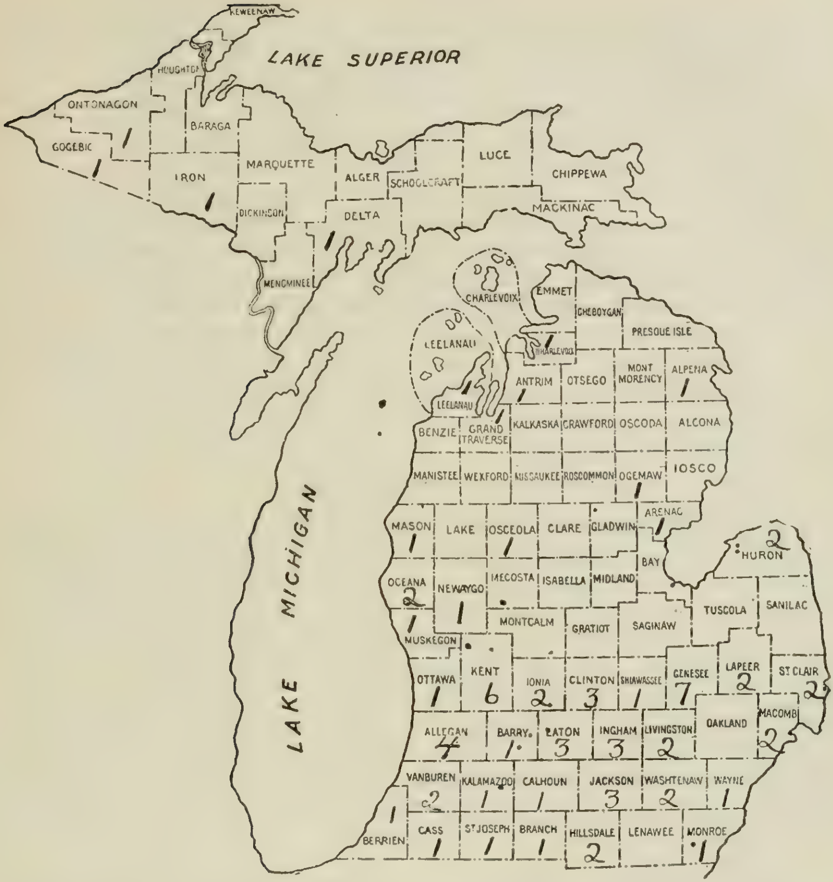
REPORT OF EXTENSION WORK IN DAIRY HUSBANDRY

BY H. E. DENNISON

The work of the Dairy Extension Specialists for the period closing November 30th has been carried on in conformity with the plan of work adopted July 1st. Cow Testing Associations, Pure Bred Bull Associations and County Dairy Campaigns have received the greater part of the Specialists attention, but a considerable portion of time is necessarily given to judging and demonstration work at Fairs during the autumn months. Work of a miscellaneous nature must necessarily be handled from time to time.

COW TESTING ASSOCIATION

It is the opinion of the Dairy and Extension Departments that Cow Testing Association work is of prime importance in Dairy Cattle Improvement in Michigan. Problems relating to better care and feeding and eliminating unprofitable cows are solved directly through this medium. It also serves as one of the most logical and effective agencies through which to attack the scrub sire problem. As a result of definite efforts on the part of the Cow Testing Association testers during the past five months, practically every Association in the State reports 100 per cent pure bred bulls in its herds.



There were in operation on July 1, 1922, sixteen Cow Testing Associations, as follows:

Livingston County Co-operative Cow Testing Association.
Lapeer County Co-operative Cow Testing Association.
Western Allegan County Co-operating Cow Testing Association.
Wayland County Co-operative Cow Testing Association.
Wayne County Co-operative Cow Testing Association.
Northern Van Buren County Co-operative Cow Testing Association.
Oceana County Co-operative Cow Testing Association.
Kent County Co-operative Cow Testing Association.
Newaygo County Co-operative Cow Testing Association.
Parma (Jackson) County Co-operative Cow Testing Association.
South Van Buren County Co-operative Cow Testing Association.
Emmet County Co-operative Cow Testing Association.
Kalamazoo County Co-operative Cow Testing Association.
Eaton County Co-operative Cow Testing Association.
Calhoun County Co-operative Cow Testing Association.

Rives (Jackson) County Co-operative Cow Testing Association.

There have been organized and started since that time ten new Associations, as follows:

Berrien County Co-operative Cow Testing Association.
Calhoun—Battle Creek County Co-operative Cow Testing Association.
Cass County Co-operative Cow Testing Association.
Ogemaw County Co-operative Cow Testing Association.
Dickinson County Co-operative Cow Testing Association.
Antrim County Co-operative Cow Testing Association.
Genesee, No. 1 County Co-operative Cow Testing Association.
Genesee, No. 2 County Co-operative Cow Testing Association.
Macomb County Co-operative Cow Testing Association.
North Eaton County Co-operative Cow Testing Association.

As a result of the publicity given Association work through Dairy and Alfalfa Campaigns in October and November a number of new Associations are in process of organization in Clinton, Kent, Washtenaw and Ontonagon Counties.

BULL ASSOCIATIONS

Very little definite work has been done as yet to organize bull associations. The limited number of men on the force and the great demand on them for the various lines of work has made it impossible to do very much with the bull association work. One Guernsey Association of three blocks has been formed in Presque Isle county and gives promise of developing into a strong organization.

The Dairy and Alfalfa Campaigns conducted in Clinton, Kent and Washtenaw counties discovered over 300 men who are interested in getting pure bred bulls. Quite a large proportion of these men are interested in bull association work. Preliminary steps have been taken to put on pure bred bull campaigns in Lenawee and Oceana Counties. Developments in either case will depend on the activities of the local Breeders Associations. This work will be carried on through the Lenawee County Holstein Breeders Association, and the Oceana County Jersey Breeders Association, respectively. The plan is to sell to groups of breeders or associations home grown bulls of good individuality and pedigree. This system properly supervised will result in the inexpensive distribution of good bulls and will eliminate the undesirable features of commercial bull sale plan as carried on in many sections of the State.

DAIRY AND ALFALFA CAMPAIGNS

As indicated above, campaigns have been carried on in Lenawee, Hillsdale, Eaton, Jackson, Otsego, Cheboygan, Clinton, Kent and Washtenaw counties. These campaigns serve the double purpose of carrying dairy information to the class of farmers most in need of it and at the same time definitely locating areas and individuals most interested in Bull Associations, Testing Associations, community breeding, etc. Campaigns are scheduled for a number of counties during February and March.

DAIRY TOURS

Three Dairy Tours have been held during the period covered by this report. These tours took the usual form of visits to five or six practical dairy farms where up-to-date methods and equipment were used. The main topics were discussed "The Herd Sire", "The Individual Cow" and "Economical Feeding". Branch, Gratiot and Hillsdale counties were covered and considerable interest in better dairying resulted.

BREEDERS AND DAIRYMENS MEETING

Local and State Breeders' Associations have shown considerable activity during the past five months. Members of the Extension force have met with a total of twenty-four Associations during this period. The Dairy Extension program has been presented at these meetings, and the closest co-operation between breed organizations and the Extension force is making for rapid progress in general dairy work.

EXHIBITS

Exhibits have not played an important part in the program of work to date. Due to the rather extensive exhibit put on at the Michigan State Fair by the U. S. Department of Agriculture all efforts along this line were abandoned. Members of the Extension Department assisted with the Government exhibit during the State Fair week. One exhibit worthy of attention was staged in October at the National Dairy Show through the co-operation of the American Guernsey Cattle Club and the Extension Specialists. Five grade Guernsey females ranging from one-half blood to thirty-one thirty-seconds and one of the three pure bred bulls owned by the Leer Guernsey Breeders Association of Alpena County were selected by the Specialists as an educational exhibit to show the result of fourteen years of upgrading work through pure bred bulls owned in an Association. The exhibit was commented on very favorably by a large number of people and apparently was a success in every way. The American Guernsey Cattle Club financed the exhibit.

JUDGING

During the months of August, September and October a considerable portion of the specialists' time is required in judging work at County and regional fairs. Twenty-four such shows were judged during the past season. In doing this work an attempt has always been made to make it as much of an educational feature as possible. In this sense the expenditure of time is possibly justified.

MISCELLANEOUS

Many lines of work not included under the above headings have received attention. Chief among these being the Boys' and Girls' Club camps and meetings where instruction was given along dairy lines to club members, community meetings, farm visits, etc.

PERSONNEL AND ORGANIZATION OF FORCE

The personnel of the Dairy Extension force has undergone some changes during the time covered by this report. Mr. J. A. Waldron was compelled on account of ill health to give up the work on July 1st.

The thorough, practical work done by Mr. Waldron during the last few years has made a very firm foundation on which to build the present extensive dairy development program. The present force is composed of H. E. Dennison, A. C. Baltzer, S. J. Brownell and J. G. Hays. Mr. Hays began work November 1st in the capacity of Extension Specialist, but is employed jointly by the State Holstein-Friesian Association and the College. This arrangement was considered advisable because of the large number of requests for help at Holstein-Friesian meetings throughout the State. Mr. Hays, as a practical Holstein breeder, is capable of handling this work, and when not employed in this way is available for general Extension work.

A recent plan to hasten and effectively carry out the dairy development program calls for a division of the State into districts with a Specialist located in each district. The exact division of territory for each district has not been made, but it is planned to have a Specialist in each of the following centers: Kalamazoo, Jackson, Lapeer, Muskegon, Saginaw, Ann Arbor, Marquette, and Grayling to look after the details of the work for the area comprising his district. This system will eliminate many of the difficulties caused in the past through, first—inadequate help, and second—distance of actual field operations from the Extension Specialists. It will also enable the Specialist to become definitely acquainted with his territory, its conditions and needs, and thus be in a position to attack those problems intelligently and effectively.

Mr. Robert Addy, formerly in charge of the Allegan County Cow Testing Association, but more recently sales and advertising manager for Chapin & Company, will begin work on December 1st in the district including the counties in the southwest part of the State. Temporarily, at least, he is located with County Agent O. I. Gregg at Allegan. Negotiations are under way for men for other districts and as rapidly as competent men can be found these districts will be supplied.

The Dairy Extension force recognizes the value of leadership in launching and carrying out its present program. The vision of Prof. Reed in planning the program and his enthusiasm and support in carrying it through goes far toward the success of the work.

The following table gives a brief summary of the work done along Dairy Extension lines from July 1, 1922 to December 1, 1922:

Projects	Meetings Attended	Attendance	Meetings Addressed	Attendance at Meetings Addressed
Cow Testing Association	37	1,160	33	937
Bull Association	7	228	7	223
Breeders' and Dairymen's Association	36	3,311	30	3,173
Boys' and Girls' Clubs	6	275	6	275
Community	2	60	2	60
Creamery	....	....	....	....
Farm Bureau	....	....	....	....
Market Milk	....	....	....	....
General Farmers and Business Men	4	396	4	396
Dairy and Alfalfa Campaigns	894	16,200	894	16,200
Judging County Fairs	24	....	....	....
State Fairs	1	....	....	....
National Dairy Show	1	....	....	....
National Dairy Show	3	175	....	....
Dairy Tours	7	222	6	150
Farmers' Day—U. P.	6	3,050	6	3,050

REPORT OF EXTENSION WORK IN ANIMAL HUSBANDRY

BY V. A. FREEMAN

Animal Husbandry Extension work had been carried on in Michigan previous to June 30, 1922, under a project entitled "Live Stock" and a sub-project entitled "Sheep Husbandry", but no Extension Specialist had been engaged in Animal Husbandry work for several months. Since July 1, 1922, a project entitled "Extension Work in Animal Husbandry" by means of specialists has been effective. The work was started by the undersigned July 14th. Only the one specialist has yet been employed for the various phases of work covering beef cattle, sheep, swine, and horses.

Excellent co-operation has existed between the work by the Extension Specialist and the extension work done by the regular teaching and experimental staff of the Animal Husbandry Department of M. A. C., exchange of work often having been arranged to improve schedules.

Replacement of scrub bulls, boars, and rams with purebreds of correct type has been attempted, and will be continued the coming year. Hog feeding methods leading to economy of production and suitable feeds to supplement the home grown supply as well as the importance of minerals have been brought to the attention of hog raisers. The recent development of "baby beef" production makes training for its management and feeding imperative and work along this line will be attempted soon.

Ultimate state goals might be expressed in having every breeder of horses, beef cattle, sheep or swine use nothing but purebred sires of good type and individuality; in having all breeders and feeders using the most economical systems of management consistent with quality production and adapted to their particular conditions; in education of feeders and furnishing guides so they may be able to select for themselves supplementary feeds for an ever changing market that will most economically supply the nutrients and qualities lacking in their home grown supply of feeds; in developing a study of markets so that meat production may be of a quality and type that meets the consumers' demand with as much spread as possible between selling price and cost of production. Within the next year the number of swine producers making the maximum use of pasture, keeping suitable minerals before their animals throughout the year, and economically supplementing his rations should be greatly increased.

The number of shepherds dosing their sheep and lambs regularly for stomach worms may be doubled or tripled. Other lines of work are likely to be more or less general unless additional specialists are added to the force.

The work that has apparently accomplished most has been through local meetings held in the yards or barns on farms where meetings have previously been arranged and advertised by county agents. There has also been considerable interest in selection demonstrations with the live-stock judging at county fairs. This interest seems to be on the increase and will do much to fix correct type in the minds of beginners and breeders that do not get out to the larger stock shows. County breed associations are a great aid in extension work.

The greatest factor in putting across this work has been the work of county agents. Practically all meetings and demonstrations have been arranged by them or in co-operation with them. Some time was spent in training Boys' and Girls' Club Members in live stock judging in co-operation with club leaders.

Considerable time has been spent recently in working up material for an extension bulletin on Swine Feeding.

From the U. S. Department of Agriculture assistance would particularly be appreciated along the line of methods of extension that have proven successful elsewhere. Much literature has been available to me which is greatly appreciated and any personal help will be gladly accepted.

REPORT OF EXTENSION WORK IN HORTICULTURE

BY T. A. FARRAND

The more important lines of work followed during the season of 1922 were: 1st, general orchard and fruit fertilization, with demonstrations and experiments as to its economic use in fruit growing. 2nd, Spraying for the control of insects and diseases. 3rd, Pruning in which case a large number of field meetings were asked for and held. Along other lines a few grafting demonstrations were asked for in the Upper Peninsula, top-working some undesirable varieties into sorts better adapted to that section for market purposes.

Some very important work was done in making surveys where grapes and other fruits were being planted in relation to sites, elevation, etc., to avoid continuous losses from low temperatures in winter months and also to lessen the danger of damaging frosts in late spring and early fall. A plant disease survey of raspberry plantings was made in Van Buren and Berrien Counties. The party was made up of specialists from departments at Washington, Michigan Agricultural College, County Agents, representatives from the canning industry, and a large number of growers.

The conclusions reached after this survey were: 1st, the disease conditions were such that the life of the red and black raspberry industry in Michigan was threatened. 2nd, the extension service should assist and, if necessary, formulate such plans as would help eradicate the diseases. 3rd, The extension service should stimulate interest in better cultural practices through fertilization, cover crops, and a general soil building program, because observations indicated that many plantations were suffering from a lack of plant food and not disease. A suggested plan which appears workable, is an organization of raspberry growers with the object of growing certified plants as free from disease as is possible through a very systematic rogueing, destroying the discarded plants. This work to be done not alone with the object of growing healthy plants for sale, but also to aid in saving and making the plantation more profitable for a longer time. To carry out such a program would require a large amount of assistance.

With the rapid development of the apple industry in practically all parts of the state, and with its success in the future in view, the question of a standard list of commercial varieties and its general adoption in planting is most important. With the co-operation of the Executive Board and Horticultural Committee of the Michigan State Horticultural Society and the members of the Horticultural Department at the College a standard list was agreed upon. This list must be sold to the growers of Michigan and adopted, as it is one of the most important factors in successful marketing. An illustration of this point was given in the past season when the writer was called upon and, in attempting to help out, took a buyer to a fruit section with a fruit exchange. The buyer asked what varieties they had. The manager said, "Oh, we have fifty-seven varieties", and the buyer lost all interest. These conditions are general.

The writer, with officers of the State Society, attended the annual meeting of the National Nurserymen's Association, presented and discussed a plan with them regarding the possibility of certifying stock true to name. This, if worked out, would be of unmeasureable value to both growers and nurserymen and should be made National in its scope.

It would seem a wise and economic line of work to advocate the topgrafting of the thousands of Duchess apple trees, including several undesirable kinds that are grown in many of the northern counties, into some one or two of the standard commercial winter varieties best adapted to those sections. The past season's experience with thousands upon thousands of bushels of Duchess apples produced for which there was no market was disastrous. There have been other years with the same experience in the past, and no doubt there will be more in the future, because this variety comes on the market at a season of the year when there is competition from all other kinds of fruits and also with later varieties of apples of higher quality produced in more southern sections.

Interest is increasing rapidly in methods of common storage and also in some type of artificial storage adaptable to the larger orchards as well as to use in towns and smaller cities. Some method of handling the fruit is necessary to avoid forcing the apples on to the markets all within a small period of time.

Interest is increasing in the irrigation of small fruits of all kinds. There is practically no information as to profits per acre from the installation of such systems and the problems arising with the rapid development and expansion of the fruit industry in the state are innumerable.

The following is a brief outline of the more definite projects worked on and some comparison is offered as to the results and interest in them. The general orchard and fruit fertilization project created more interest among the fruit growers than the combined activities of all other lines of extension work in fruit growing. The results from the experiments and the large number of demonstrations put on in connection with them proved unsound. The splendid co-operation of the county agents in placing the demonstrations and in getting a few records and a large amount of observation from them, reinforced by the records from the Experiment Station was the dominating factor in creating interest. From these results, the use of commercial fertilizers has narrowed down to the application of nitrogen, either in the form of nitrate of soda or sulphate of ammonia, with a very large percentage being used in the form of sulphate of ammonia. The demands for information along these lines before the growing season commenced was constant and by May 1st the supply of all available nearby nitrate of soda and sulphate of ammonia was exhausted. Much more would have been used if it could have been gotten in time. A few reports of county agents are included showing these results.

Pruning: There has always been more or less interest in this practice and we are fortunate today in having a standard system of pruning generally adopted throughout the country. Research work throws some light on the problem, and this phase of the work was emphasized in field and lecture meetings. The general practice of over-pruning young apple trees which has been followed was headed off, recommending a light system of pruning and more fertilization as an economic practice.

Spraying demonstrations were put on in relation to spraying and the necessity of thorough spray practice was most strongly emphasized. Knowing that this is the one strong connecting link between success and failure in orcharding, no opportunity was lost at any lecture or field meeting to drive home the necessity of this important practice, giving the latest up-to-date recommendations from the Experiment Station. The writer is convinced that a very large percentage of the failures in controlling destructive insects and diseases is due to the carelessness and lack of doing rather than to a lack of knowledge. Many interesting meetings were held where spraying experiments were being carried on in which the standard sprays were being compared with some newer practices. The standard sprays, as recommended, demonstrated their value in the perfect control of the disease or insect for which they were applied. In most instances, where losses do occur it is not a question of demonstrating, spending a large amount of time putting on spraying demonstrations, but it is rather a question of hammering in what the growers already know. In the case of some insect, hard to control, proving destructive in some new area, then it is advisable to put on thorough spraying demonstrations as in the case of the grape berry moth control in Van Buren County vineyards.

The demands for assistance at Extension Schools and other organization meetings were far in excess of the number that could be cared for even though other members of the staff in the Horticultural Department assisted in doing Extension work, attending both lecture and field meetings during the summer. The attendance, etc., is not included in this report. The number of demands for lecture meetings ranks first, then follows the field meetings and demonstrations and last, the field meetings, auto tours, etc., visiting demonstrations and many orchards which showed the results of practices as applied by the grower, as well as visits to the experiment station which showed the progress of interesting experiments.

The writer attended 45 field and demonstration meetings, visiting 415 farms with an attendance of 1,780, and 93 lecture meetings with an attendance of 1,140. All the different types of meetings are important in their season and the demand for them is greatly increasing.

Briefly, Michigan, as a fruit state, occupies first place in its acreage of cherries and small fruits, and it is well up in the front row in tree and other kinds of fruits which are rapidly increasing. This expansion of acreage in fruits, together with the problems previously mentioned in this report, clearly indicates the necessity for a program of extension activities, backed by a strong research program which required a number of trained men to give even a part of the service required to keep pace with the problems.

REPORT OF EXTENSION WORK IN POTATO IMPROVEMENT

BY J. W. WESTON

The object of the potato project is to increase net profits from potato growing by elimination of waste in production and by securing the advantages of marketing a standardized quality table stock and certified seed stock product.

The 1921 reports show that of 42 counties reporting, 3,732 farmers treated seed potatoes for disease control, involving 13,720 acres; that 1,902 farmers sprayed potatoes on a total of 10,073 acres and that cultural methods were changed on 1,648 other farms including 7,332 acres.

The 1922 reports show that 56 counties reporting 4,924 farms, treated seed potatoes for disease control involving 22,170 acres, an increase of 64% over that of 1921; that 2,201 farmers sprayed potatoes on a total of 10,731 acres, and that cultural methods were changed on 2,304 other farms including 12,443 acres; covering (1) hill selection, (2) fertilization, (3) correct spacing, (4) correct planting dates, (5) farm management practices. This means that only 6% of the acreage of potatoes was planted with treated seed and less than 3% of the acreage was sprayed with Bordeaux Mixture.

USE OF IMPROVED SEED

1,585 farms introduced Michigan Potato Producers' Association certified seed to the extent of 64,168 bushels. 1,893 acres planted with certified seed gave an average increase of 41 bushels to the acre as compared to seed formerly used. There is usually used in Michigan at least three and one-half million bushels of seed each year for planting, indicating that less than 2% of the seed planted is from certified or selected seed stock. The state average yield for ten years is only ninety bushels per acre. An increase of 41 bushels per acre would mean a state average of 131 bushels per acre providing good seed was used by all. A total of 64,168 bushels of certified seed would plant 6,417 acres yielding 840,627 bushels of good seed capable of planting 84,063 acres in 1923 of 24% of the state acreage.

SPRAYING

Spraying demonstrations were conducted in 56 counties, seven counties had 21 organized spray rings, containing a membership of 94 farmers and 64 high pressure (175 lb.-200 lb.) sprayers were introduced by County Agents for controlling insect and foliage diseases. Thirty-two farms, reporting spraying tests with checks, show an average increase in yield of the sprayed over the unsprayed of 57 bushels per acre at a total cost of $9.48 per acre for an average of five sprays. This cost includes cost of materials, labor, depreciation, interest, etc. The requirement of the Michigan Potato Producers' Association, that all parties applying for inspection must spray effectively, has resulted largely in establishing the practice. Every farmer reporting that sprayed for the first time this year, is converted to spraying.

FERTILIZATION

Fertilizer demonstrations to increase quality yield, and net return per acre were held in 12 counties. The standard demonstration included a high test fertilizer containing a high percentage of Potash and Acid Phosphate. Ten counties had 25 planned demonstration plats, showing an average increase in yield, in the fertilizer over the unfertilized plats of 45 bushels per acre. An average application of 400 lbs. of fertilizer was used on the majority of plots.

HILL SELECTION

The practice of hill selection of potatoes at digging time is of special importance to the interested and experienced potato grower. Two farmers report results of last year's selection as follows:

A one acre seed plat planted with hill selected seed yielded 432 bushels per acre. Ten acres in balance of field, planted with field run seed, yielded 290 bushels per acre. Another report gave 190 bushels per acre from hill selected seed and 114 bushels per acre from field run seed stock.

STRAIN TESTS

A strain test of seed from one source distributed to 50 different farms in 16 different counties gave very interesting results. The yields have varied from a high point of 325 bushels per acre to a low point of 155 bushels per acre with an average of 238 bushels per acre for all. The range of 170 bushels per acre in yield is due to spraying, favorable soil conditions and better cultural methods. In this case we have a quantity of seed with a known parentage, and common origin, but grown under many and varying conditions that would tend to prove that with good seed, sufficient fertility, proper spraying, and with soil in good physical condition, yield can be fairly well stabilized.

SEED TREATMENT

Proper seed treatment of potatoes is one of the requirements of the Michigan Potato Producers' Association. Through the influence of this organization, the practice of spraying increased to the extent of 64%, in 1922 as compared to 1921. The practicability of spraying has been fully demonstrated, but as yet only 6% of the acreage in the state is sprayed.

TIME OF PLANTING

Demonstrations of time of planting Irish Cobblers were conducted in the northern part of the state, to determine the dates best suited to plant Irish Cobblers in order to get the best results in production of stock for seed. The 1922 results would not conclusively establish a practice. However, for the season of 1922 the dates giving best results on time of planting were between June 5th and 18th, considering largest yields and greatest amount of marketable tubers.

DISTANCE OF SPACING

Several demonstrations on distance of spacing were carried on in order to increase yields and decrease oversized tubers. Results with Irish Cobblers indicate that hills 12 inches and 18 inches apart in rows 3 feet apart, gave the largest total yield. The 12 inch spacings, however, had a large number of small potatoes, while the 24 and 30 inch spacings produced fewer potatoes and a number of over-sized unmarketable ones.

FARM MANAGEMENT STUDIES

The best place for the potato crop in the rotation is generally conceded to be after a legume crop, especially alfalfa, sweet clover or common clover. The preparation of this land brings in the question of time of plowing—fall plowing vs. spring plowing of sod on heavy sandy loam soil. The increase of the fall plowed plot over the spring plowed plot, of two acres each, resulted in a 50 bushel increase, or 25 bushels per acre.

PARENT SEED FARMS

Three farms have been selected for starting the work next year, under the parent seed farm project, one farm taking a carload of White Rurals and two farms taking 125 and 75 bushels respectively of Irish Cobblers.

REPORT ON ACTIVITIES

The potato program for the state was projected through 25 lecture meetings in the spring with an attendance of 922 people. The field meetings were held at 179 field demonstrations with an attendance of 3,850 people, while 280 farm visits were made where the owner had either demonstrations or the field showed something of merit or was strikingly abnormal. In these field meetings attention was brought to weak or diseased plants that should be removed from the seed plot. The type of plant growth and the shape of the tuber desirable to save for seed purposes was pointed out.

The Extension Specialist selected hills from farms of the best growers, showing particular vigor, freedom from disease and of good varietal type. These hills will be taken to the Experiment Station and increased by the Plant Breeder and Plant Pathologist in co-operation with the Extension Specialist. The increase will be selected for type vigor and freedom from disease.

REPORT OF EXTENSION WORK IN POTATO SEED CERTIFICATION AND CULTURAL PROJECTS

BY H. C. MOORE

Forty demonstrations were conducted in co-operation with the County Agricultural Agents. These demonstrations showed the value of seed selection, spraying, seed treatment and the use of common fertilizers in bettering the quality of the potatoes and increasing the yields.

1,020 acres of potatoes were inspected for certification in 1921; 654 acres passed the inspection and were certified. Approximately 81,400 bushels of certified seed potatoes were sold at a premium of approximately 75 cents a bushel over U. S. No. 1 table stock. The inspection and certification work has benefited the potato industry of the state by making available for Michigan growers seed stock of high yielding strains, free from varietal mixtures and comparatively free from disease. Furthermore, the good cultural methods followed by growers of certified seed serve as demonstrations to other growers. In 1922, 3,196 acres of potatoes were listed for inspection. 2,429 acres passed the inspections and were certified. The average yield per acre of fields that were certified was 166.8 bushels. Michigan's estimated average yield per acre of potatoes for 1922 was 104 bushels. Forty-eight counties undertook the inspection and certification of seed potatoes in 1922. There will be offered for sale during the season 1922-1923 approximately 270,000 bushels of certified seed potatoes at a premium of approximately 60 cents a bushel over U. S. No. 1 table stock.

The inspection and certification work has stimulated an interest in seed treatment, high pressure spraying, better seed, etc.

To compare Michigan certified seed potatoes with seed from other sources, over 1,000 bushels of Michigan certified seed were placed in tests in southern Michigan, Iowa, Indiana, Illinois, Ohio and Pennsylvania. In each test the Michigan certified seed and the seed with which it was compared were grown under the same soil and cultural conditions and accurate records of the yields were secured.

The following table gives a summary of the results secured:

State	No. of Records Secured	Average increased yields per acre secured by Michigan Certified Seed
Southern Michigan	11	40
Iowa	6	61.2
Indiana	21	63
Ohio	69	42.8
Illinois	61	44
Pennsylvania	65	68.5

In order to test the yield qualities of the various lots of potatoes planted for inspection, 131 strains of Russet Rurals and Green Mountains were secured from growers who applied for the inspection work and were planted in a demonstration plot. The yields varied from 368 bushels per acre for the best strain to 108 bushels per acre for the lowest yielding strain. Work with these strains is being continued in 1922. Two hundred and forty other strains of potatoes have been planted this year in a similar test, the data on this test, however, are not yet tabulated.

A variety test demonstration consisting of 29 varieties planted at the Michigan Agricultural College showed that the Russet Rural or Late Petoskey was the best late variety and that the Irish Cobbler was the best early variety.

The following is a statistical summary of the work done between July 1, 1921 and November 30th, 1922:

Total number of demonstrations	47
Farm visits made	641
Meetings Held at Demonstrations	41
Attendance at such meetings	674
Lecture Meetings	62
Attendance at Lectures	3,713

REPORT OF EXTENSION WORK ON UPLAND SOILS

BY GEO. GRANTHAM

The Extension Work in Soils is divided into two divisions, namely, first, the work done in the field during the growing seasons which includes field demonstrations and field meetings on the same and, second, the extension schools held during the winter months of January, February and March.

The extension schools are given over largely to discussions of those problems which are brought up by farmers and the discussions of individual problems in soil management. Lime drives consist of meetings to discuss the liming situation, with special emphasis placed on the Soiltex soil acidity method. Demonstration work with the use of different amounts of limes are carried on.

The results of fertilizer on various soils and crops as brought out by experimental work forms a basis for phases to be emphasized.

The ultimate goal in the above projects is to have more farmers in each community to practice the methods advised.

The most successful method of teaching the subjects is at field meetings where results of demonstrations can be discussed. Simple soil tests in the field also afford good methods of bringing about results.

The County Agent is a very vital factor in keeping before the farmer soil management methods, as well as assisting in demonstration work.

Results from demonstrations are gratifying and their success toward the state goal is as much as could be expected. Some extension schools which are scheduled in connection with entertainments scarcely warrant the time and expense necessary to carry them on. However, where regular extension meetings are scheduled good results have been obtained.

The use of the Soiltex soil acidity method in community gatherings, obtaining lime requirements and the extent of acid soils in the community, serves as an illustration of the method employed.

The amount of miscellaneous and emergency work carried on during the year cannot be estimated. However, this is no small part of the work.

The demonstrations now under way will be carried on for the next year. Special emphasis will be placed on lime drives.

REPORT OF EXTENSION WORK ON MUCK SOILS

BY PAUL M. HARMER

Outline of Work

The extension work on muck soils in Michigan for the year 1922 has been conducted by the writer. One-fourth time is assigned to extension work, one-half to experimental and one-fourth to the teaching of a course in Muck Soils.

The extension work as now conducted falls into five separate phases.

1. *Work with the county agents and farmers.* Whenever county agents or farmers are confronted with problems in the farming of muck and ask for assistance, it is given either by letter or, if necessary, by a personal visit to the area.

2. *Field demonstrations and field meetings.* The field demonstration, generally located through the county agent, is a means of carrying to the community information on cultivation, cropping and fertilization

of muck soils. Wherever satisfactory results are secured a field meeting of the neighboring farmers is held sometime during the summer.

3. *Winter meetings.* Wherever it is considered advisable or requested either by county agents or farmers, winter meetings of the muck farmers are held in different localities, at which places the results of the previous year's work are discussed and plans made for the coming year.

4. *Michigan Muck Farmers' Association.* This association, with a membership of approximately 1,800, holds one or two meetings each year. The writer is secretary of the association. The winter meeting held at East Lansing, January 31 and February 1, 1922, had an attendance of 85.

5. *Muck Farmers' News Letter.* At intervals during the year mimeographed letters on timely subjects pertaining to muck farming are sent to all muck farmers on our mailing list. At present this numbers around 1,800.

DEVELOPMENT OF MUCK FARMING IN MICHIGAN

The total area of the muck and peat soils of Michigan is estimated at between 3,000,000 and 4,000,000 acres. The value of this land varies from practically nothing up to $1,800 per acre, the variation being due to the extent of reclamation, coupled with a highly developed intensive system of truck farming on the muck in certain sections of the State. A majority of owners of uncultivated mucks are ignorant of the possibilities of the muck for the crop production. Of the total area of organic soils in the state probably not more than three to five per cent have been reclaimed by even slight drainage. Little has been done in the development of the soil on a large proportion of these reclaimed areas. Considerable is being used for wild hay or pasture, but, generally with both, yield is low and quality poor. Many times these idle muck areas are surrounded by fertile upland soil, often lying adjacent to the farmstead, and in that way lowering the value and injuring the appearance of the farm. Where a high development of muck farming has been reached, very good returns are secured, values of $800 to $1,000 per acre from such crops as celery and onions not being uncommon.

A higher percentage of failures occurs in the farming of Michigan muck and peat lands than is true in the farming of any other type of soil. This is due to the fact that the problems confronting the muck farmer are decidedly different and harder to overcome than those met with on mineral soil. Sufficient drainage, without excessive drainage, must be secured, and proper cultural methods must be adopted before crops can be produced. Danger of summer frosts and winter killing, the chemical composition of the muck, high or low lime, and market demand must be considered in the selection of crops to be grown. As the natural fertility of organic soils is generally depleted after a very few crops have been grown, fertilization of the muck soon becomes an important factor in crop production.

The area of muck in the State now used for the production of celery has been placed at 3,500 acres, of which 3,000 acres is used for commercial growing. A considerable area also is used for the growing of mint. Both of these crops have a limited market demand. At the present time there is a considerable overproduction of mint oil resulting in a market decrease in price. Until further work has been done on the storage of celery for winter and spring market, any large increase in celery acreage would likewise result in rendering celery growing unprofitable. Because of these facts, the tendency in the extension work with muck soils during the past season has been to direct the prospective muck farmer toward a system of diversified farming, with a selection of crops which are in general demand, adapted to muck soils and which, at the same time, are able to withstand without injury, a considerable amount of frost. Special emphasis has been placed on proper fertilization, the rate of application per acre also being considered in the arrangement of the plots for 1922.

REPORT OF EXTENSION WORK IN INSECT CONTROL

BY J. H. HARMAN

On May 10th, 1922 the writer took up his duties as Extension Specialist in Entomology.

Since that time the aim has been to give the farmer and grower all possible assistance in his fight against his insect enemies. This has been accomplished by means of demonstrations and advice setting forth the use and application of sprays and dusts, and adopting other remedial measures.

Demonstrations have been carried on concerning the peach-tree borer, flat-headed apple tree borer, grape-berry moth, pea-louse, codling-moth and chinch-bug.

The county agents contributed toward the success of all demonstrations, through publicity, lining up the farmers likely to be benefited, and lending personal assistance.

The great majority of all demonstrations were purely emergency work. The outstanding illustration is that of the fight against the chinch-bug in the southern part of the State.

About the seventeenth of July, 1922, we were called upon by the county agent of Monroe county, to assist him in the fight against the chinch-bug. The writer with two assistants went over the situation taking into consideration the type of soil, general location, and intensity of infestation. The local newspapers co-operated to the extent of publishing directions for measures of control, also announcing the time and place of demonstrations.

The first demonstration was launched near Monroe to which were invited farmers of the immediate vicinity. Actual operations were carried on and the tar and dust barriers were laid down halting the advance of the insect. After the demonstration, the three of us scattered over the county, selecting sites suitably located so that the entire county was covered in six demonstrations. These created considerable enthusiasm enabling those who witnessed them to repeat operations on their own farms and at the same time to show their neighbors how it was done. Demonstrations were also carried on in Lenawee and Branch counties.

Exhibits displayed at the State and small county fairs were composed of miniature models showing methods of control for different insects, cages containing living specimens, also photographs of actual field operations were displayed. The writer answered many inquiries regarding farm, garden and household insect pests.

REPORT OF EXTENSION WORK IN APICULTURE

BY EDWIN EWELL

The educational program of the Extension Specialist has consisted of many personal interviews with beekeepers; participation in a series of "beekeepers' schools" in thirty counties, each school lasting two days; local meetings held in various counties at which demonstrations were given whenever possible; and automobile tours which offer one of the most desirable methods of demonstration. The tour is advertised in advance by the officers of the county associations and beekeepers assemble at the starting point with their automobiles, visiting a series of apiaries during the day. Each apiary as visited is examined by the entire party and demonstrations made of the treatment of diseases, requeening, making of comparison of various apiaries, the beekeepers in attendance recognizing superior methods of manipulation and the advantages of using up-to-date equipment. At the same time discussion of problems and manipulation helps to discover the individual needs of beekeepers in the party. Proper methods of manipulating supers, care of the honey crop and its preparation for market were given much attention; the proper manipulation of new swarms and reasons for swarm control were also stressed.

Exhibits were displayed at four fairs: Detroit, Saginaw, Bay City and Midland. Opportunity was presented to meet a large number of beekeepers in each case. The College exhibit consisted of samples of honey from various sources, mounts of honey plants, wall charts and samples of foulbrood, all of which excited much interest. In fact it was necessary to give an almost continual lecture during each day of each fair. Opportunity was presented to make plans for Extension work among new prospects. It has been our policy to instruct beekeepers regarding bee diseases and to encourage each beekeeper to become expert in its detection and treatment. Inasmuch as disease is spread throughout the Lower Peninsula with the exception of the northern tier of counties, it is hoped that in each community at least one or two men, having become expert in handling disease, may serve as leaders in influencing others to adopt better methods.

Work done in five counties in the Upper Peninsula indicated a wonderful opportunity for the development for the beekeeping industry there. Although there are few commercial beekeepers in the Upper Peninsula at the present time there are many beginners. Large areas of clover, raspberry, fire-weed, golden-rod and other honey-plants produce annually a large quantity of nectar which goes to waste for lack of bees to gather it. Although the winters are long and cold, large quantities of snow and a steady temperature enable the beekeeper to winter his bees successfully, if proper care is given.

Since the Upper Peninsula is at present free from disease, "Cloverland" is becoming very attractive to beekeepers.

The increase in acreage of sweet clover throughout the state is assisting beekeepers generally since raspberry and other nectar sources from wild plants are becoming fewer.

Through the co-operation of large numbers of County Beekeepers' Associations, and of the County Agricultural Agents, it is becoming possible to reach more and more beekeepers each year. Several county beekeepers' associations have definite schedules for meetings for the year, the plan providing for from two to five meetings, most of which are held during the summer months. The interest exhibited by these County Associations depends largely upon the officers in charge. However, there is a growing feeling that co-operation is beneficial to all and that the County Beekeepers' Associations offer the best means to this end, both educationally and commercially.

REPORT OF EXTENSION WORK IN DRAINAGE AND HOUSEHOLD ENGINEERING

BY O. E. ROBEY

Household Engineering

The work in household engineering has consisted of holding demonstrations in septic tank construction and furnishing plans for various household conveniences, also attendance of meetings where household conveniences are discussed.

A "knock down" form has been developed to be used by County Agents in their counties. This form is so constructed that it can be easily removed without damage and can be used by a great many people in the same county. It greatly simplifies septic tank construction. Three counties have been provided with the forms.

Drainage

Drainage extension work has consisted of making drainage surveys and providing plans for drainage systems. A drainage campaign was put on in Sanilac county according to the plan submitted last year and has proven quite successful. A series of meetings were held during February and March to bring before the people the value of drainage, as a result 22 farmers asked to have drainage plots of various sizes ranging from 7 to 25 acres put in on their farms. Also 68 farmers asked to have their farms surveyed for future drainage systems. Five demonstration meetings have been held in the fields which were attended by about 240 people. Publicity articles were run in the County papers regarding the work.

Surveys have been made on 28 farms comprising 2,240 acres and visits made to 25 other farms where sugestions have been made. Nine demonstration plots comprising 147 acres were drained. These plots required 6,000 rods of ditch and practically twenty carloads of 100,000 tile. The work was delayed owing to our inability to secure the services of a tiling machine when desired, also the coal shortage delayed delivery of tile. Much more work could have been done as there were several other applicants.

While the work was not as successful as it might have been, under more favorable economic conditions, yet when it is remembered that this county in previous years put in scarcely a carload of tile in intensive farm drainage, a start at least has been made in this much needed farm practice.

Thirteen days were spent in testing the tile of the various manufacturers of the state. Many interesting points were brought out by this test which will serve as a basis for future study.

Summary

No. of days spent in office	90
No. of days spent on tile testing	13
No. Demonstration meetings held	19
No. attendance	457
No. Lecture meetings held	39
No. attendance	2572
No. of farms visited	213

REPORT OF MARKETS AND RURAL ORGANIZATION EXTENSION SERVICE

Hale Tennant—Director.
Gifford Patch, Willard Cribbs—Assistants.

Rural organization and Marketing extension work in Michigan, during the year ending December 31, 1922, was of the same type and character as the four years preceding and was based entirely on the theory that permanent assistance to farmers, in organizing their industry, can only be brought about by the establishment of substantial, self-supporting farm organizations, in which the farmers carry all the responsibility.

No patronizing attitude is assumed toward Agricultural organizations in any respect and no actual marketing service is contemplated. Special attention is given to the continuous maintenance of farm control in co-operative institutions and careful study to the sociological factors, incident to the development and holding of local leaders capable of carrying full responsibility for marketing undertakings. Farmers are given to understand that efforts in co-operative organizing are their own efforts and not, in any sense, promotional institutions of the College. In advising farmers relative to organization problems, the general efficiency of the industry is kept in mind in addition to the marketing function around which the organization is to be built.

Co-operative marketing institutions must be able to meet legitimate competition and should make some additional savings, but many undertakings in organization which are considered worth while from the point of view of the general benefit of the industries, might be questionable if established entirely on the basis of the savings between the co-operative system and the old regime. The marketing function is the common interest which forms the best basis for agricultural organization, but efficiency in production as well as efficiency in marketing and the still more difficult problem of co-ordinating production with demand, must be taken into consideration in formulating organization plans.

The efficiency of agriculture as an industry, both in production and marketing, is the goal sought and, as the lack of organization is recognized as the chief weakness of Agriculture and constitutes the principle barrier to the attainment of high efficiency, our opinions and recommendations are given with full consideration to this larger aspect of Agriculture.

As the assistance which the Markets Department gives to farmers is of an advisory character, the work has been, from the start, piecemeal, attention being given to groups of farmers, here and there, in response to requests, sometimes to local problems and sometimes to the interests of groups of locals. As the work progressed, however, more and more attention has been given to comprehensive plans for organization of the commodities grown by the farmers in the state and more recently attention has been given to the uniting of the Commodity Exchanges in the state along lines in wheih they have common interests.

The Michigan State Farm Bureau, organized in the beginning, as a mass organization of all farmers in Michigan, seemed an ideal organization to harmonize and unite the various Commodity exchanges, as well as represent the interests of the farmers in this state through the federation of County Farm Bureaus and, during the last two years, plans have been gradually formed through which the Farm Bureau assumes the functions above described. This plan, having become a fixed policy of the Michigan State Farm Bureau in collaboration with the Markets Department and, being state-wide and comprehensive in character, market and organization reports are formulated on the basis of this plan for the purpose of clarifying the description of the work and, also, indicating the relative importance of the various proects.

Reports of the work in Markets and Rural organization are given in the following order:

I. (a) Michigan State Farm Bureau in its function of co-ordinating and harmonizing the commodity exchanges in the state and, also, promoting and assisting this type of organization.
   (b) New Membership campaigns of Michigan State Farm Bureau.

II. FARM BUREAU ECONOMIC ACTIVITIES.

(a) Traffic.
(b) Purchasing.
(c) Wool and Minor Products.
(d) Publicity.
(e) Produce Marketing Department.
(f) Legislative.
(g) Seed Department.

III. COMMODITY EXCHANGES.

(a) Michigan Potato Growers Exchange.
(b) Michigan Elevator Exchange.
(c) Michigan Livestock Exchange.
(d) Michigan Milk Producers Association.
(e) Michigan Fruit Growers Exchange.
(f) Michigan Sugar Beet Growers Exchange.

IV. PROBLEMS OF LOCAL ORGANIZATIONS.

V. GENERAL EDUCATIONAL WORK.

I. (a) Farm Bureau Function in Uniting Commodity Exchanges.

The Markets Department has assisted the Michigan State Farm Bureau in the development of plans for co-ordinating the work of the Michigan Potato Growers Exchange with the Michigan Elevator Exchange through which locals in each Exchange can receive recriprocal service. Similar work is planned in co-ordinating the efforts of other commodities exchanged.

Assistance has also been given to overcoming the suspicion fostered by certain factors that the Farm Bureau was attempting to absorb Commodity exchanges, rather than build a federation of the same. Suggestions of various kinds have been elaborated for the combined use of the services of the State Farm Bureau by the Commodity Exchanges and the uniting of the efforts of all on certain major problems, such as transportation and legislation. This Department has also given direct assistance to the Farm Bureau and the Michigan Live-stock Exchange in their joint plans for the establishment of a co-operative Live-stock Commission House at Buffalo. The assistance of this Department was also given to the Farm Bureau's efforts and plans made to promote a federation of the existing Co-operative Fruit Associations. Considerable progress was made so that the completion of this project is expected during the coming year, which will make the fifth major commodity organization affiliated with the Michigan State Farm Bureau.

The Farm Bureau, through its Produce Department, has served the celery and onion growers and now, in response to a general demand, the Markets Department is suggesting plans for the development of a statewide organization of the Muck crop interests.

I. (b) New Membership Campaigns of Michigan State Farm Bureau.

Assistance to the Farm Bureau in its membership drive consisted in numerous talks to farmers, explaining the organization plans of the Bureau and its economic functions and general services.

II. (a) Traffic.

Four major undertakings of the Farm Bureau in transportation and traffic matters had the assistance of this Department. First, the abandonment of certain spur Railroads in Michigan was undertaken by the Pere-Marquette Railway Company and opposed by the Traffic Department of the Farm Bureau. This case was won before the Interstate Commerce Commission. Second, a strong effort was initiated during the year to abolish the Zone System in Railroad rates in Michigan. This case is now in progress. Third, The Farm Bureau, in co-operation with the Michigan Potato Growers Exchange, has compelled a readjustment of rates on potatoes so that Wisconsin, Minnesota and other north-western shippers are compelled to pay rates in accordance with the distance hauled. Fourth, The Farm Bureau, in co-operation with the Michigan Potato Growers Exchange, is preparing a case against the Central Traffic Association in an attempt to secure permanent relief from the severe car shortage which has prevailed in Michigan for several years during the potato shipping period.

II. (b) Purchasing.

Members of the staff of the Markets Department have participated in numerous conferences in the re-organizing of the Farm Bureau Purchasing Department with the College in formulating Dairy Rations, etc. The total volume of business of the purchasing department is as follows:

Total number of Cars................	1921	1277
Total Number of Cars................	1922	1745
Total Volume of Business—February 1st, 1921, to February 1st, 1922............		$760,708.96
Total Volume of Business—February 1st, 1922, to January 15th, 1923............		$815,466.27

(c) Wool and Minor Products.

Assistance of the Department has been given to the the re-organizing of the Wool Marketing Department of the State Farm Bureau. The handling of the clip during the past season for the most part has been on a strictly co-operative basis with fairly satisfactory results. The volume of business of the Wool Department during the past three years has been as follows:

1920-1921-1922

1920	3,522,050	pounds sold for..........	$575,143.08
1921	2,688,313	pounds sold for..........	598,905.03
1922	320,079	pounds sold for..........	130,487.60
Total	6,530,442		$1,486,535.71

(d) Publicity.

The State Farm Bureau, having determined to publish a state paper, has asked the assistance of the Markets Department for plans for co-ordinating the publicity departments of the various Commodity Exchanges, meetings with the Board of Directors of the Michigan Potato Growers Exchange and the Michigan Milk Producers Association have been attended in developing plans for this project.

(e) Produce Marketing Department.

A Produce Marketing Department has been established by the Michigan State Farm Bureau in response to a general demand for the purpose of marketing co-operatively poultry products, vegetables and other perishables. Mr. Patch of this department has given considerable of his time to advising with the management and to presenting the plans of same to local farm organizations in the state.

(f) Legislative.

Assistance in legislative matters has been confined to plans for securing a more mature and united opinion among farmers on prospective legislation and on co-operative enacting laws.

(g) Seed Department.

Assistance to this division has been limited to a conference with the management relative to financial operations and to developing a market for Michigan grown seed.

July 1st, 1920—July 1st, 1921.....	750,000
July 1st, 1921—July 1st, 1922.....	1,000,000
July 1st, 1922—July 1st, 1923.....	1,500,000 (Estimated)

III. COMMODITY EXCHANGES.

(a) Michigan Potato Growers Exchange.

The Markets Department has been in close touch with the Michigan Potato Growers exchange during this year and all members of the Markets Staff have given more or less attention to its marketing and transportation problems.

The Michigan Potato Growers Exchange has suffered severely from car shortage, both box and refrigerator, and a vigorous effort has been made in conjunction with the Michigan State Farm Bureau to get permanent relief from this shortage. An organized effort has been made, also co-operating with the Michigan State Farm Bureau, to secure an adjustment of rates on potatoes as between Michigan and northwestern points. Substantial progress has been made along this line and competitive points will be compelled to pay rates consistent with the distance of markets.

The attention of the Markets Department has also been directed towards the problem of standardization and improvement of the grade of the Exchange output and research work is in progress on the major markets, the condition of Michigan potatoes arriving and other problems in the co-ordinating of potato producers with demand. The Markets

Staff has participated in numerous conferences with managements and Boards of Directors, having to deal with general organization and financial problems of the Exchange and to relationship with the Michigan State Farm Bureau.

(b) Michigan Elevator Exchange.

The Markets Staff has given assistance to the Elevator Exchange largely in an advisory capacity in financial and general organization problems. Considerable attention has also been given to local elevator problems and their relationship with the Exchange. The Michigan Elevator Exchange has made excellent progress during the year and now has an A-1 rating in both Dunn's and Bradstreet's reports on the basis of $75,000 Net assets. The volume of business of the Elevator Exchange during three months in 1920 was approximately $250,000, during the year 1921, $3,750,000 and during 1922, $4,141,000.

III. (c) Michigan Livestock Exchange.

Considerable attention of this Department was given to the Michigan Livestock Exchange in formulating plans for the establishment of co-operative Commission Houses in Detroit and Buffalo. The Commission House at Buffalo was established through the combined efforts of the Exchange and the Michigan State Farm Bureau in Co-operation with the State Farm Bureaus in Indiana and Ohio. The members of the Staff attended several conferences in developing plans for the Buffalo House.

Still further attention has been given to the relationship of the Livestock Exchange and the Michigan State Farm Bureau.

The Commission House in Detroit, having been in operation seven months, is now handling 33% of the receipts. The Buffalo House, during November and December, has handled about 30% of the total receipts on that market.

(d) Michigan Milk Producers Association.

Assistance to the Michigan Milk Producers Association has been confined to efforts in co-ordinating the work of this organization with the Michigan State Farm Bureau and the presentment of plans combining the Publicity Departments.

(e) Michigan Fruit Growers, Inc.

The Michigan State Farm Bureau, during the year, made a vigorous effort to federate the Michigan Fruit Growers organizations in the state into a state-wide Exchange and considerable progress was made in the formulating of plans for such an organization. Numerous conferences and meetings in the Fruit Belt were attended by members of the Staff in working out this plan, which contemplates co-operation with the Michigan State Farm Bureau, as well as, co-operation with the Federated Fruit and Vegetable Growers of America. It is expected that this project will be completed during the coming year.

(f) Michigan Sugar Beet Growers Association.

The work of the Department in this division has been limited to conferences with some leaders in the sugar Beet Industry relative to future plans for organization.

IV. LOCAL ORGANIZATIONS.

A large per cent of the time of the Markets Staff has been given to problems of local organization. These organizations show great varieties of types and include Co-operative Elevators, Livestock Shipping Associations, Potato Marketing and Warehouse Associations, Cold Storage and Pre-cooling Plants for perishables, Co-operative Creameries, Co-operative Cheese Factories, Co-operative Fruit Packing Houses and Cooperative Milk Distributing Plants. Many of these local units need to be reorganized and re-financed, due to losses occurred during the after-war depression. Many local membership Associations have been re-organized under the new Non-profit Stock law, which is now considered preferable where any considerable amount of capital is involved. The number of these local associations is steadily increasing and our records now show a total number of about 508.

V. GENERAL EDUCATION WORK.

Numerous talks and addresses by members of the Marketing Staff have been given on Rural Organization and Marketing problems to Granges, Farmers Clubs, Gleaner Organizations, Agricultural Institutes, County Farm Bureaus and meetings of local Co-operative Marketing Associations, as well as meetings of Commodity Exchanges, Farm Bureaus, etc.

The marketing staff is compelled to accept a large number of invitations of this kind and consider this class of work as being of genuine value but is not cultivated and preference is given to the major efforts along the line of well defined organization projects which have been undertaken.

REPORT OF EXTENSION WORK IN LAND CLEARING

BY L. F. LIVINGSTON

Agitation for land clearing has been carried on for some time in Michigan, but it was not until August 1, 1921 that the efforts were crystallized and the Michigan Agricultural College established a land clearing section with L. F. Livingston in charge and A. J. McAdams as assistant. Due to the early growth of the work, Geo. Amundson was employed in March as an assistant.

The first problem that confronted this office was a general survey of the land clearing conditions of the state with special reference to the Upper Peninsula where more cleared land was essential. The survey brought out several facts regarding the agricultural situation of the

Upper Peninsula. 1—Land clearing and its problems is the most important question facing the farmers in the cut over sections. 2—The average of cleared acres per farm is too small to make economical and successful farming. 3—The rate of clearing, based on a ten year average was one acre per farm per year, much too low for the development of resources at hand. 4—The reasons for this slow rate of clearing by the settlers already on the cut over regions, were found to be several—lack of knowledge of the economical methods of clearing, wasting explosives through improper handling and buying, too many accidents due to improper use of explosives, and a lack of interest and understanding of the problems of land clearing on the part of the bankers and business men.

The problem in the lower peninsula is one of getting rid of the stumps that are interfering with the cultivation and economical farming of the fields that are cleared and have been farmed for a number of years.. We do not consider a piece of land cleared until *all* of the stumps have been removed.

Land clearing in the cut over regions of Michigan, while ordinarily classed as reclamation work, differs from most reclamation projects. Here the soil, rainfall and climate are naturally provided and adapted to agriculture. The sole obstacle is the brush and stumps which must be removed before the land can be tilled. Every farmer in this territory is confronted with the same problem and every farmer without exception, can be benefited, financially and socially by an intensive campaign in better, quicker and safer methods of clearing.

In this respect, land clearing differs from other reclamation work in the state. It is a problem which must be worked out by every settler and some program is absolutely essential to take care of the farmers now developing new homes, and new men will eventually develop the rest of this territory, to give them the benefit of all past experience and some definite aid, if this territory is to become a prosperous farming section.

To accomplish this it was necessary to interest all who have mutual enterprises in the cut over sections of Michigan to the importance of more cleared acres and to secure their continued co-operation.

The work was carried on through the county agents and the extension system, by (1) demonstrations in uses of dynamite and picric acid, (2) land clearing exhibits at county fairs, (3) meetings with county boards of supervisors, (4) winter farmers meetings, (5) business organization meetings, (6) newspaper publicity, (7) land clearing schools, (8) landclearing story contests, and (9) picric acid distribution.

Thirteen demonstrations in the uses of dynamite and picric acid were held in the fall of 1921 in the Upper Peninsula with an attendance of 2170 farmers. This clearly indicated the need of education in the use of explosives as well as need of education in the use of stump pulling equipment. From our survey it is estimated that one-third of all the dynamite used for agricultural purposes is wasted because of improper methods or the wrong material being used. Further, it was found that one-half of all stump pullers purchased should never have been bought. Either the type of clearing was not adapted to stump pullers or the machine was not equipped with the right attachments. The carload system of buying explosives was introduced and saved the farmers thousands of dollars. By correcting these faults the cost of clearing has been and can be reduced to a much lower figure.

It was necessary to get the land clearing movement before the eyes of every one in the Upper Peninsula and to spread broadcast, information that the Michigan Agricultural College was in a position to help farmers in their land clearing work. To do this we chose to visit all county fairs with a land clearing demonstration by means of models, showing the best approved methods and tools as well as featuring models of home made devices. During the fall, twelve counties were visited and a total of 19,575 people viewed the land clearing exhibit. In personal talks with various farmers the need of education was again evident.

To further the educational end of land clearing and to secure the necessary funds to carry on our plans, we appeared before nine county boards of supervisors asking them to appropriate sufficient funds to carry on a series of land clearing schools in their counties. We received an aggregate appropriation of about $8,000 to carry on thirty-eight land clearing schools in ten counties of the Upper Peninsula. In the majority of cases the boards of supervisors were far sighted enough to see the necessity of land clearing and in several cases they attended the schools in a body.

During the winter a total of 105 land clearing meetings were held in the farming regions with an attendance of 10,045 people. A conservative estimate shows 65% were farmers. Twelve counties were covered during the winter. Moving pictures portrayed the best approved methods of clearing land and arrangements were made for the land clearing schools to be held in the spring. These meetings demonstrated a good healthy interest in land clearing and our office has been called on continually to aid farmers in their problems. These meetings also revealed that it was necessary to show better uses of material on hand and to bring about a cheaper rate of clearing as well as to get cheaper materials in the hands of the farmer. In many cases it was found the cash outlay played an important part in the manner in which the farm was cleared. In other cases the SPEED of clearing was the determining factor with no particular attention paid to the cash outlay. Therefore, that which is economic land clearing for one may be impossible for another, and this is one of the many reasons for bringing land clearing education as near the individual's back door as possible.

Besides interesting farmers, it was necessary to show business men and bankers the direct relation between more cleared acres and more rapid development of their community or city. It was our privilege to appear before 25 business men's meetings with an attendance of 1,792. By gaining their co-operation and support, the land clearing movement took enormous strides forward. During the winter two county agents' conferences were held where land clearing was the main subject of discussion and in the majority of cases, land clearing was one of the major projects in the year's work of the county agents. From the county agents' reports we find they spent 25.8% of their time on land clearing.

Since last fall this office has supplied twenty-five newspapers of the Upper Peninsula each week with land clearing material. Our clipping book shows that these papers as well as several in the Lower Peninsula and numerous magazines have been supplied with information. Because of our wide publicity campaign, we have received requests for information on land clearing and possibilities of land clearing stretching from New York to Seattle and as far south as Central America.

To interest the young folks and also to further interest the older folks in land clearing, a land clearing story contest was carried on in each of six counties. Over a thousand essays were submitted and prizes were awarded to the winners.

Practical land clearing education was carried on this spring by a series of 38 land clearing schools conducted in ten counties of the Upper Peninsula. Over 1,000 people attended these schools. The school was made up of eight cars donated by the railroad; 18 men, supplied by the college; six stump pullers, supplied by stump puller companies; two tractors, supplied by tractor companies; and dynamite and dynamite tools from three powder companies, as well as Picric Acid. The "learn by doing" method was adopted in the field, clearing a total of 86 acres. About 2,706 farmers took the complete course. We know that all who attended these schools carried away some ideas which will be beneficial to them.

This fall another series of land clearing schools were held in the north east section of the lower peninsula. Twenty-seven stops were made in seventeen counties and 4,700 people attended. 1,300 of these completed the course and will receive certificates. The train was run in the same manner as the Upper Peninsula train but carried a crew of 10 men instead of 20. Of course this necessitated our cutting down on the amount of equipment carried. This series, as the other, was a success from all points of view.

It was also the duty of this office to distribute 1,874,000 pounds of war salvage picric acid to the farmers of the state. This was done through the county agent system, farm bureaus organizations and county clerks. Twenty-four cars, or 550,000 pounds were placed in 17 counties of the Lower Peninsula and the remaining 20 cars, or 457,000 pounds were distributed in 14 counties in the Upper Peninsula. It is estimated that 22,000 acres of land were cleared with this explosive at a saving to the farmers of about $143,770.00.

	No.	Attendance	Counties Visited	Days
Demonstrations held	13	2,170	8	15
County Agent Conferences	3	60	....	5
Exhibits at county fairs	12	19,575	12	44
County board meetings	9	247	9	9
Business men's meetings	25	1,792	14	30
Farmers' meetings	105	10,045	12	75
Land clearing schools—U. P	38	10,000	10	70
Land clearing schools—L. P	27	4,700	17	38

The goal as set for the Upper Peninsula has been and will be 60,000 acres per year for five years. It is based on a five acre per farm production and will at the end of five years give the average farmer sufficient cleared land to make him independent of logging or mining operations. Statistics will be gathered at the winter meetings to show the actual results but from the preliminary work that we have done it is safe to say that we will gain our 60,000 goal.

For the coming year the State is divided into three parts. A. J. McAdams will cover the west half of the Upper Peninsula, Geo. Amundson will have charge of the east half of the Upper Peninsula and N. A. Kessler will have charge of the northeast section of the Lower Peninsula. As time goes on it is hoped that another section will develop in the north west section of the Lower Peninsula, but at the present time we have not the time nor the funds to carry on work in other sections. In each section winter land clearing meetings will be held with the view of talking over the individual problems of the farmer, of developing the carload systems of co-operative buying of explosives, and laying the foundation for the land clearing schools which will follow in the spring and fall. These schools or demonstrations this year will be held as a truck train and each county will have its schools as a unit rather than be a part of a large program as was the case last year. With the work outlined as above, our forces should be three times as efficient as before because we will have three series of meetings going at once and three series of schools or demonstrations running at the same time.

It is suggested and strongly urged that the U. S. Department of Agriculture establish ways and means whereby experimental work can be done in land clearing. Land clearing, though the oldest type of work in the United States, has had the least attention paid to it from a scientific standpoint. If, through the Washington office, a section was established which would do nothing but investigate new means and new apparatus for clearing some of the millions of cutover areas which are now in the process of becoming farms, it would be government money well expended.

REPORT OF EXTENSION WORK IN POULTRY HUSBANDRY

BY C. M. FERGUSON AND R. D. URE

The demand for poultry work throughout the State by both farmers and breeders has shown a remarkable increase during the fiscal year. For a greater part of the year one extension man has been alone in handling the work. After August 15th Mr. Ure was added to the staff but the demand for work is still far from being met. Both specialists worked on culling demonstrations up until October 15th when Mr. Ure commenced the inspection of certified flocks for the Michigan Baby Chick Association and the organization of demonstration farms.

The demand for further information on poultry disease has increased tremendously. The extension service was unable to cope with requests and in order to handle the situation the co-operation of the Department of Bacteriology was solicited. Dr. Stafseth of that department has rendered invaluable assistance in broadcasting information on poultry diseases particularly Bacillary White Diarrhea, Avia Tuberculosis, Chicken Pox, Roup, Fowl Typhoid and Fowl Cholera. Flocks are now being tested in a wholesale way for Bacillary White Diarrhea under the supervision of Dr. Stafseth. All birds sent into the Department for diagnosis are also handled in this way. In addition to this service Dr. Stafseth has attended several field meetings, poultry tours and association meetings on subjects pertaining to diseases of poultry.

Poultry culling demonstrations have during the past year occupied the greater part of the specialists' time from June 1st to October 1st. Lectures on rearing chicks, incubation, brooding and care of growing stock made up the spring work. Fall and winter meetings are given over to discussion and lectures on poultry house construction, feeding for production, plant management and disease control.

The number of demonstration farms are being established this year in various counties. Only flocks of good quality are being used for this purpose. It is essentially a breeding proposition with the object in view of supplying eggs and stock of high quality to the surrounding community. These flocks will be culled and the breeding stock selected each year by the extension specialist. Records as to the amount and cost of feed consumed, number of eggs produced, the time of matching in relation to profit are being kept by the flock owner. These records extending over a period of years will prove of interest showing as they will the effect of selective breeding and careful culling in relation to egg production.

Demonstrations and meetings will be held at these farms during the year to discuss timely subjects of interest with poultry men.

Five of the more popular breeds namely, Barred Rocks, White Leghorns, Rhode Island Reds, White Wyandottes and Anconas are being used and it is our intention to popularize these breeds and by so doing reduce the number of breeds kept thus standardizing poultry products. The extension staff has not been large enough to carry out this work on a scale as large as was anticipated. However, a number of farms have been inspected, supplied with the proper forms and are now keeping records. The counties in which these farms are located are: Berrien—1, Cass—2, Branch—4, Barry—5, Livingston—7, St. Clair—3, Huron—3, Antrim—1, Benzie—1, Kent—1.

The Poultry Department and the Michigan Baby Chick Association are co-operating in a project to improve the quality of the stock sent out as baby chicks by the hatcheries. Numerous complaints were made at culling demonstrations during the summer by people who had purchased baby chicks and received inferior stock. It is hoped that by the system of certification the public will have greater confidence in the baby chick industry.

During the late summer and early fall the hatchery men culled the farm flocks which supplied them with hatching eggs. These flocks are in turn inspected by an extension specialist who scores them accordingly to a score card. This report is submitted to a certification committee, elected by the Association whose function it is to pass the stock or reject it. Up to the present time 130 flocks have been inspected for this purpose.

It is hoped that the culling work can be put on such a basis that there will be available in each county some persons who are efficient in culling and selection.

In view of the fact that the Department has sent out approximately 5,000 plans of the Michigan type poultry house it is obvious that the housing conditions of Michigan Poultry are improving. We already have in the State a large number of these houses completed and many more under construction.

Demonstration farms should aid materially in demonstrating proper feeding and housing methods as well as what profits may be realized from farm poultry.

The certification of flocks supplying eggs to commercial hatcheries will be a great step towards improving the quality of chicks. Approximately 10 million were distributed this year from hatcheries in the state.

The lecture method of presenting material has been relied on for winter meetings. Summer meetings which are largely culling demonstrations are smaller and more actual demonstrating can be done and more time spent with the individual. We have found that culling can best be taught by taking a small group giving them a thorough drilling on the major points to be considered than allowing them to cull a few flocks under our supervision.

The County Agents have been instrumental in the organization in advertising of campaigns and meetings held within the counties. Requests for work are filed by the Couty Agent at the Extension Office and he is alloted as much time as possible in making up our schedule. It has been impossible to meet all the requests or to give as much time to the counties as they have requested. This has resulted in a hurry-up schedule, making many of the meetings too short to permit the discussion of phases of poultry work which would be brought up subsequent to a formal meeting. Home demonstration agents have in some counties taken over entirely the poultry work within the county. On the other hand others have made it a part of their efforts insofar as it applies to the farm home with no attempt to work with commercial poultrymen. Farm women through their clubs and societies show a very keen interest in all phases of poultry work. Boys and Girls Club Agents have done a great deal to make poultry work attractive to the Junior farmer. Poultry clubs and judging contests have added materially to the interest of the boys and girls in this project. The club agents are in many cases assisting the County Agent in organizing the county poultry program.

Summary of meetings and demonstrations:

Farm Visits	502
Meetings held at Demon	355
Attendance at such meets.	6314
Lecture meetings	73
Attendance at lectures	9459

BULLETINS

OF THE

Agricultural College Experiment Station

ISSUED DURING THE

YEAR ENDING JUNE 30, 1923

POTATO CULTURE IN MICHIGAN

Special Bulletin No. 117

BY H. C. MOORE

Favorable climatic and soil conditions, combined with relatively close markets, make Michigan one of the leading potato growing states of the country. The potato crop is also a good one to include in a standard rotation where such conditions exist to favor its development. It is one of the best cash crops grown in the state, and the average returns per acre are usually greater than for any other general crop.

Based on the five year average, 1915 to 1919 inclusive, Michigan was fourth among the states in order of total production. The average yield for this five year period was 75 bushels per acre. There were 340,000 acres of potatoes grown in Michigan in 1921 with a total production of 27,200,000 bushels. Figure 1 shows the distribution of the potato crop in Michigan in 1921. It will be seen from this map that there were only four counties in the state that produced less than 50,000 bushels each.

The potato thrives best in a cool, moist climate, and the quality is best when the crop is grown on light loamy soils. These conditions, which prevail in many sections of the state, are very favorable for the production of good yields of high quality potatoes.

Michigan is advantageously located with reference to markets. Ohio, Indiana, Illinois and Kentucky are dependent upon the northern potato growing states for a large portion of the potatoes they consume. A five-year average of potatoes needed annually by Ohio, Indiana and Kentucky in excess of the crop produced in these states is as follows: Ohio, 20,999 car loads; Indiana, 9,502 car loads; Kentucky, 6,920 car loads. The distance between this large potato consuming center and the potato producing center of Michigan is comparatively short. The cities and large towns of Michigan also furnish excellent markets for Michigan potatoes.

Great advancement has been made in Michigan during recent years in the co-operative marketing of potatoes. Through this movement, new and more direct markets are being developed.

The following table of statistics from the Federal Crop Report for Michigan, January 1, 1922, furnishes a continuous history of the potato production in Michigan since 1866. It will be seen from this table that the greatly increased total production secured during the latter part of this fifty-six year period is due to increased acreage and not to increased yields to the acre.

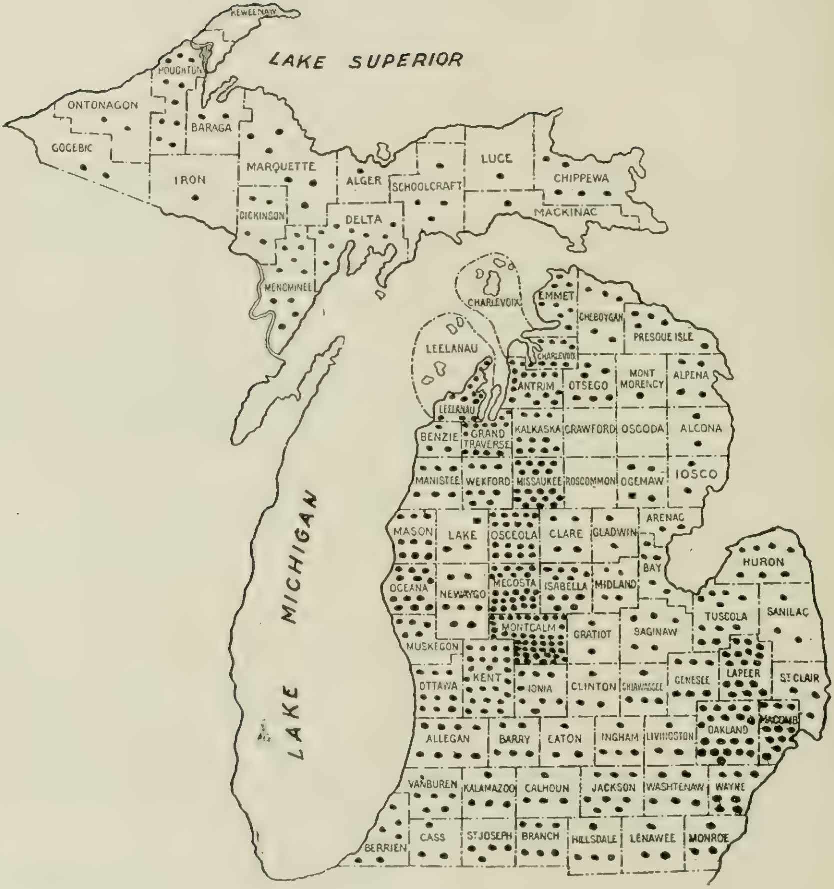


Fig. 1. Potato production in Michigan in 1921. Each dot represents approximately 50,000 bushels.

TABLE 1. Statistics of the Michigan Potato Crop from 1866 to 1921.

Year.	Acreage harvested.	Average yield per acre.	Total production (000 omitted).	Average price December 1.	Total value, (000 omitted).	Average value per acre.
	Acres.	Bushels.	Bushels.	Dollars.	Dollars.	Dollars.
1866	45,793	110	5,037	0.39	1,962	42.84
1867	58,974	98	5,750	0.52	3,007	50.99
1868	60,106	94	5,650	0.42	2,354	39.16
1869	48,387	155	7,500	0.29	2,199	45.45
1870	73,684	95	7,000	0.52	3,645	49.47
1871	87,500	68	5,950	0.75	4,441	50.75
1872	91,045	66	6,009	0.56	3,353	36.83
1873	92,133	75	6,910	0.70	4,836	52.49
1874	87,368	87	7,601	0.57	4,318	49.42
1875	85,000	125	10,625	0.27	2,872	33.79
1876	86,363	55	4,750	0.66	3,135	36.30
1877	92,771	83	7,700	0.35	2,696	29.06
1878	91,000	76	6,916	0.48	3,313	36.41
1879	97,300	113	10,995	0.41	4,508	46.33
1880	97,300	112	10,898	0.41	4,468	45.80
1881	131,589	58	7,632	0.80	6,106	46.40
1882	138,168	90	12,364	0.43	5,317	38.48
1883	142,313	83	11,812	0.41	4,843	34.03
1884	146,582	90	13,192	0.25	3,298	22.50
1885	148,048	87	12,880	0.34	4,379	29.58
1886	146,568	80	11,725	0.39	4,573	31.20
1887	149,499	30	4,485	0.72	3,229	21.60
1888	119,599	72	8,611	0.33	2,842	23.76
1889	200,981	78	15,677	0.33	5,173	25.74
1890	202,991	58	11,773	0.64	7,535	37.12
1891	209,081	96	20,072	0.24	4,817	23.04
1892	188,173	62	11,667	0.53	6,183	32.86
1893	195,700	75	14,678	0.45	6,605	33.75
1894	215,270	62	13,347	0.43	5,739	26.66
1895	236,797	101	23,916	0.16	3,827	16.16
1896	208,381	88	18,338	0.19	3,484	18.37
1897	175,040	72	12,603	0.43	5,419	30.46
1898	178,541	79	14,105	0.27	3,808	21.33
1899	173,185	66	11,430	0.32	3,658	21.12
1900	171,453	97	16,631	0.26	4,324	25.22
1901	273,676	81	22,168	0.68	15,074	55.08
1902	270,939	72	19,508	0.41	7,998	29.52
1903	268,230	78	20,922	0.49	10,252	38.22
1904	262,865	121	31,807	0.29	9,224	35.09
1905	241,836	67	16,203	0.56	9,074	37.52
1906	285,000	95	27,075	0.34	9,206	32.30
1907	299,000	90	26,910	0.45	12,109	40.50
1908	325,000	72	23,400	0.58	13,572	41.76
1909	365,483	105	38,244	0.35	13,385	36.72
1910	350,000	105	36,750	0.31	11,392	32.55
1911	330,000	94	31,020	0.71	22,024	66.74
1912	350,000	105	36,750	0.41	15,068	43.05
1913	350,000	96	33,600	0.53	17,808	50.88
1914	364,000	121	44,044	0.30	13,213	36.30
1915	355,000	59	20,945	0.56	11,729	33.04
1916	320,000	48	15,360	1.60	24,576	76.80
1917	378,000	95	35,910	1.05	37,706	99.75
1918	340,000	84	28,560	0.89	25,418	74.76
1919	300,000	90	27,000	1.35	36,450	121.50
1920	345,000	105	36,225	0.92	33,327	96.60
1921	340,000	80	27,200	0.95	25,840	76.00
Average	203,334	86	17,426	0.52	9,298	42.13

New land has been constantly developed and planted to potatoes. The crop has been grown on an extensive rather than an intensive basis, and very little attention has been given to the best cultural practices. Economic conditions now demand, however, that growers follow the most improved methods of potato growing, so that they can increase their yields per acre and thus lessen the cost of production per bushel. The average yield of potatoes per acre in Michigan in 1921 was 80 bushels. Many growers, however, in various sections of the state secured yields of 200 bushels or more per acre by practicing good methods of potato culture.

SOIL REQUIREMENTS

The potato crop grows best in soils that are loose and friable. In heavy, stiff soils the tubers are likely to be ill-shaped and of poor quality. Sandy loam, gravelly loam, or silt loam soils that are well drained and rich in organic matter make suitable soils for the potato crop. Potatoes will not do well in a cold, wet soil. Thorough drainage is essential.

A good potato soil should be retentive of moisture. Decaying organic matter or humus in a soil acts as a sponge and increases the soil's moisture-holding capacity. Most of the potato soils in the state are lacking in organic matter and cannot retain enough moisture through the growing season to produce a good yield of potatoes. The organic content of the soils should be increased by applying stable manure, and by following a systematic crop rotation in which such crops as alfalfa, clover or sweet clover occupy the land for a period of two years or more in the rotation. Many growers find it profitable to plow under the second cutting of clover or alfalfa for potatoes.

ROTATION OF CROPS

Potatoes are a good crop to include in a standard rotation where soil and climatic conditions are suitable for their development. The thorough cultivation that is given potatoes kills the weeds and grass, and leaves the soil in good condition for succeeding crops.

The best yields are obtained when potatoes follow alfalfa or clover in the rotation. Alfalfa and clover sods decay rapidly when plowed under, thus liberating nitrogen, phosphoric acid, and potash, which become available for the potato plants, while the decaying organic matter aids in retaining soil moisture. Timothy and other grass sods are often infested with insects, such as grubs and wireworms, which seriously damage a potato crop that follows them in rotation. Furthermore, the grass sods do not furnish as much plant food as do the alfalfa and clover sods.

It is not a good practice to plant potatoes on the same land more often than once in four or five years. A long rotation that includes alfalfa and the clovers is important for bettering soil fertility and moisture conditions. A long rotation also aids in controlling such potato diseases as Fusarium wilt, scab and black scurf that live in the soil.

The rotation to be adopted will be determined largely by soil and climatic conditions, and by the type of farming that is being practiced. Potato growers should determine what crops are best adapted to their farms, and then should maintain a definite crop rotation system.

The following rotations are suggested:

A. First year—clover; second year—potatoes; third year—barley, oats, or rye seeded to clover.

B. First year—barley, rye, or wheat seeded to alfalfa; second year—alfalfa; third year—alfalfa; fourth year—alfalfa; fifth year—potatoes, corn, or beans; sixth year—barley, rye, or wheat seeded to alfalfa.

C. First year—potatoes; second year—barley, oats, or rye seeded to sweet clover; third year—sweet clover; fourth year—potatoes, or corn.

PREPARATION OF THE SOIL

The potato requires a deep, mellow seed-bed so that its roots can extend easily into the soil and secure moisture and plant food. The depth of plowing will be determined largely by the character of the soil. Sandy types of soil are usually plowed to a depth of four or five inches, while heavier types that are well supplied with humus are frequently plowed to a depth of seven inches or more. The soil should be plowed as deeply as possible without turning up much of the subsoil.

Fall plowing generally gives good results unless the soil is very light and is subject to blowing. Heavier types of soil and those that are covered with sod are usually benefitted by fall plowing. The organic matter that is plowed under in the fall rots and puts the soil in a good condition.

Spring plowing should be done early so that the soil moisture will be conserved, and so that the organic matter that is plowed under will have time to decay partially before the potatoes are planted. This decaying organic matter will aid materially in holding the soil moisture. If the sod is cut up with a disc harrow before it is plowed in the spring, it will rot more quickly and will make a better seed bed.

Both fall plowed and spring plowed lands should be harrowed thoroughly as soon as possible in the spring, so that the soil will be put in a mellow condition and so that soil moisture will be conserved. The disc harrow is a very effective implement for cutting up sods and working them down in the soil. On fields that are stony, however, the spring-tooth harrow is more generally used. After the soil has been pulverized to the depth of the furrow slice by the disc or spring-tooth harrow, it should be gone over several times before planting time with a spike-tooth harrow or drag to smooth the surface and to kill weed and grass seedlings. Thorough tillage at this time will save much labor later in the season in controlling weeds and grass.

THE USE OF MANURE

Stable manure should be used in the rotation since it adds plant food in the form of nitrogen, phosphoric acid, and potash, improves the physical condition of the soil, and promotes the growth of beneficial soil bacteria. As far as possible, dairy farming or some other branches of animal industry should be carried on in connection with potato growing, so that manure will be available for the land.

Fresh stable manure applied late in the spring may promote the development of potato scab. This disease is caused by an organism that lives in some soils, as well as on the seed potatoes. The scab organism thrives best in alkaline or sweet soils. The ammonia in fresh manure is alkaline and tends to sweeten the soil, thus encouraging the growth of the scab organism.

In dry seasons, coarse, strawy manure when applied late in the spring may make the soil too porous and cause it to dry out quickly. It is a good practice to apply stable manure to the hay crop that precedes the potatoes in the rotation. The application should be made during the summer previous to potato planting. The growth of the hay crop is increased and there are more roots and stubble to turn under for humus. The manure rots thoroughly by the time the potatoes are planted, and much of its plant food is available for the potato crop. If applied directly to the potato crop, it is generally best to put it on during the fall or winter as a top dressing. The usual rate of application is eight or ten loads to the acre. Manure should be uniformly distributed. It should not be placed in the row where it will come in contact with the seed pieces or the growing tubers, since such practice may cause the development of potato scab.

THE USE OF LIME

The potato crop is quite tolerant of acid soil. In order to get satisfactory yields of potatoes it is necessary, however, that such crops as alfalfa, sweet clover and clover be grown in the rotation to supply plant food and humus. These plants require soils that are sweet, or rich in lime. Most of the potato soils of Michigan need lime in order to grow alfalfa and clover.

Lime applied shortly before the potatoes are planted may promote the development of potato scab, since it acts the same in this respect as does fresh stable manure. Lime, therefore, should generally be applied just previous to the sowing of alfalfa or clover, or at the time of preparing the seed beds for these crops. The usual rate of application recommended is two tons of ground limestone, or six loads or more of marl, or one and one-half tons of hydrated lime per acre.

COMMERCIAL FERTILIZERS

The potato crop should not lack for available plant food at any time during the growing season if maximum yields are to be obtained. The plant food elements in commercial fertilizers are generally more quickly available to the growing plant than are those in barnyard manure or clover or alfalfa sod. For this reason commercial fertilizers can generally be used to advantage to supplement the stable manure and sod.

The kind of fertilizers and the amounts to use is determined largely by soil and climatic conditions. Potatoes grown on sandy types of soil that are lacking in organic matter generally respond to a complete fertilizer that analyzes approximately 4 per cent nitrogen, 10 to 12 per cent phosphoric acid, and 3 to 6 per cent potash, applied at the rate of 400 to 800 pounds to the acre. Loamy types of soils that are well supplied with organic matter generally give increased yields of potatoes when they receive applications of 300 to 600 pounds of 16 per cent acid phosphate to the acre.

Of the three elements, nitrogen, phosphoric acid and potash, the phosphoric acid is the one that generally gives the most consistent results when applied in the form of commercial fertilizer. Most of our potato soils are deficient in phosphoric acid. Furthermore, stable manure and alfalfa or clover sod that is turned under contain only one-half to one-third as much phosphoric acid as they do nitrogen and potash.

Commercial fertilizers will give better results in seasons of sufficient rainfall. In very dry seasons the lack of moisture limits the development of the plants and makes them less able to utilize the plant food applied. Therefore, in sections subject to long periods of drought heavy applications of fertilizer are not so generally warranted as they are in regions where droughts are less frequent and soils are more retentive of moisture. One way of making commercial fertilizers more effective is to improve soil moisture conditions by plowing under organic matter.

Fertilizers should be placed in moist soil so that they will dissolve. They may be applied broadcast or in the furrow. When applied broadcast, they are spread by hand, by a grain drill, or by special fertilizer sower after the soil has been thoroughly fitted and shortly before the potatoes are planted. After the fertilizer has been broadcasted it should be harrowed into the moist soil. When potatoes are planted with a machine having a fertilizer attachment, the fertilizer may be sown in the bottom of the furrow. It should be distributed in a wide strip, and should be mixed with the soil so that the growing sprouts and roots will not be injured by it. In sections of the state that are subject to drought, it is not generally advisable to apply fertilizer in the furrow at heavier rates of application than 300 to 400 pounds to the acre, since heavier applications may cause injury to the young plants.

VARIETIES

The standardization of potato varieties is very important. Michigan potatoes have in the past been discriminated against in many instances because of lack of standardization in uniformity of varieties and grades. The markets cannot handle car loads of mixed potatoes satisfactorily, and for this reason it is desirable that not more than one early and not more than one late variety be grown in a community.

Observations and tests over the state, from both the production and market standpoints, indicate that the following varieties are to be recommended:

Early

1. Irish Cobbler.
2. Early Ohio.

Late

1. Late Petoskey (Russet Rural) (Petoskey Golden Russet).
2. White Rurals, including Rural New Yorker No. 2, Sir Walter Raleigh, and Carman No. 3.
3. Green Mountain.

The *Irish Cobbler* matures early. The vines are medium in size, having rather short jointed, dark green stems and large, medium dark green leaves. The flowers are light purple or rose lilac, though under hot weather conditions they may be nearly white. The tubers are roundish and often have the stem end rather deeply notched. The eyes vary from shallow to deep, particularly in the seed end. The skin is smooth and of a light, creamy-white color. The sprouts are reddish violet or magenta. This variety is of good quality and gives a fair yield under good growing conditions.

The *Early Ohio* matures a few days earlier than the Irish Cobbler. The yield, however, is generally somewhat less. The vines are rather erect with dark green stems. The flowers are white. The tubers are round-oblong with full, rounded seed and stem ends. The eyes are rather shallow but when grown under unfavorable conditions they tend to develop knobs. The skin is light pink with small, corky dots. The sprouts are carmine-violet.

Seed potatoes of the Irish Cobbler and Early Ohio varieties are in demand by growers of the southern states. Thus far Maine, Minnesota and Wisconsin have been supplying the bulk of this early seed.

The *Bliss Triumph* is a very early variety that is grown to some extent in

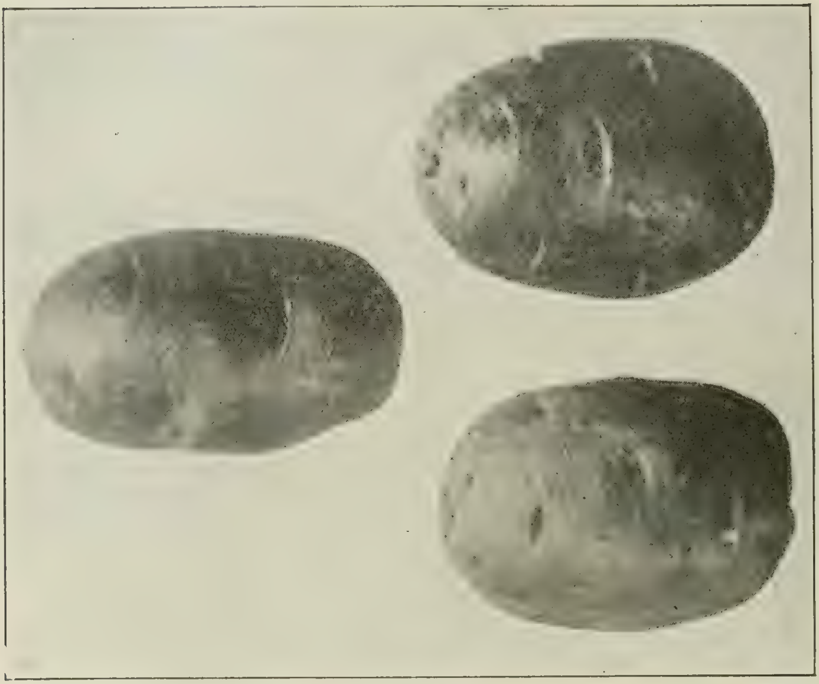


Fig. 3. Potatoes of the Early Ohio Variety.

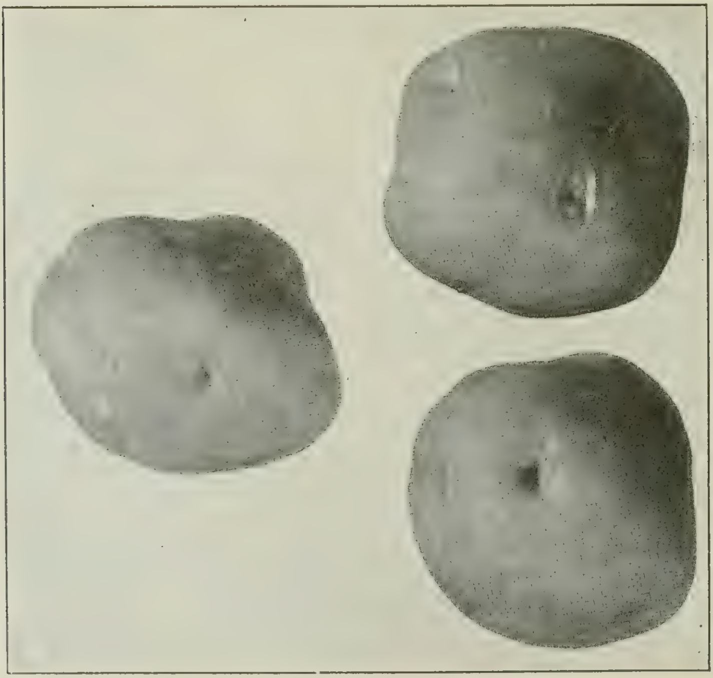


Fig. 2. Typical specimens of Irish Cobbler.

the Upper Peninsula. This variety is very susceptible to Mosaic and leafhopper injury and is grown successfully only under the most favorable climatic conditions. It is used extensively by southern growers for early planting.

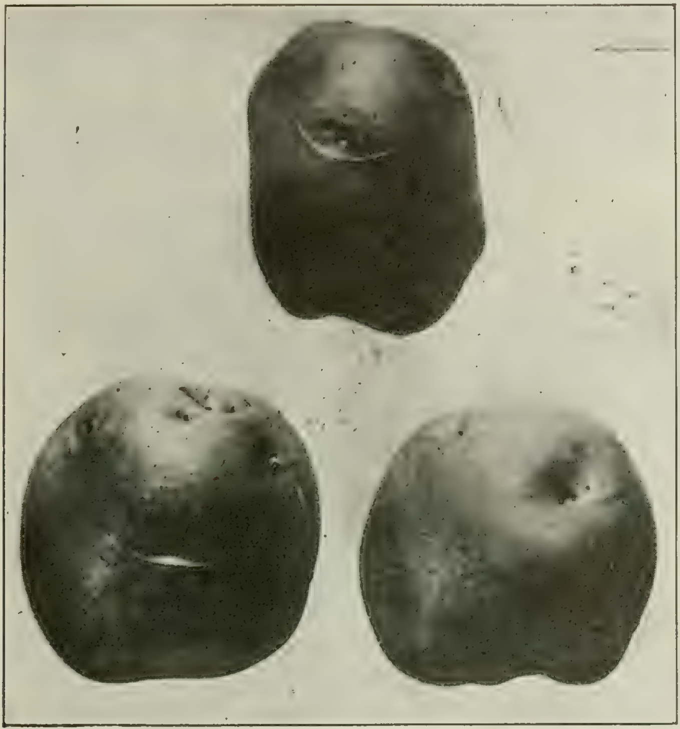


Fig. 4. The Bliss Triumph is an early pink-skinned potato.

The vines are rather erect and not much branched. The foliage and stems are dark green. The color of the flowers is rose-lilac. The tubers are small or medium size, round with rather blunt ends that usually are slightly shouldered. The eyes are slightly depressed and medium in number. The skin is a light red color.

The *Late Petoskey*, also called Russet Rural and Petoskey Golden Russet, is the standard variety of late potato for Michigan. Over 90 per cent of the 3,250 cars of potatoes shipped in 1921 by the Michigan Potato Growers' Exchange were of this variety. Of the certified seed potatoes offered for sale in 1921 by Michigan growers approximately 74,000 bushels were Late Petoskeys, compared with 5,000 bushels Green Mountain, 2,300 bushels White Rurals, amd 300 bushels of Irish Cobblers.

The Late Petoskey seems to withstand hot, dry weather conditions better than do most other varieties. It is also somewhat more resistant to leafhopper injury than other varieties that have a more delicate leaf tissue. About the only criticism against this variety is that on the heavier types of soil its skin is likely to be dark colored. On the sandy loam types of soil, when grown and harvested under good conditions, its skin is a golden russet color.

The vines of the Late Petoskey are medium-large, with the main stem upright and long-jointed. The lateral branches are decumbent. The stems are streaked with dark purple. The leaves are rather small, dark green and quite rough. The flowers are violet-purple.

The tubers are round-flattened to oblong-flattened. Eyes are very shallow. The skin is a deep russet and much netted. The sprouts are purple.

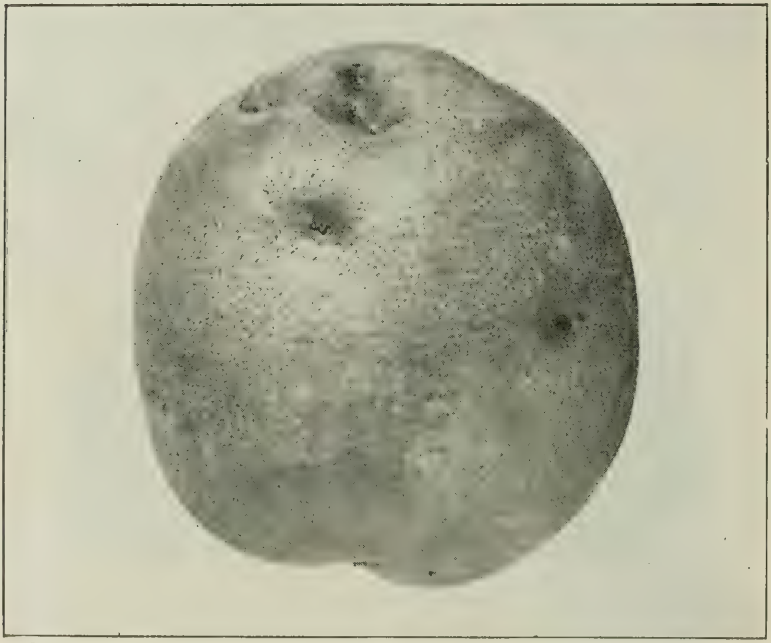


Fig. 5. An excellent specimen of the Late Petoskey (Russet Rural) potato. This is the standard late variety for Michigan.

The *White Rurals* include such varieties as the Rural New Yorker No. 2, Sir Walter Raleigh, and Carman No. 3. These three varieties bear a very close resemblance to each other in vine and tuber characteristics.

White Rurals have practically the same growing qualities as the Late Petoskey (Russet Rural). Tubers of the White Rurals, however, have white skins.

The *Green Mountain* variety is grown quite generally in the Upper Peninsula of Michigan, where the growing season is usually cool and moist. This variety is not adapted to sections where long periods of drought are of common occurrence. It matures about two weeks earlier than the Rural type of potatoes. The cooking qualities are very good. The vines are large and quite spreading by the end of the season. The stems are green and do not bear any purple markings. The flowers are white. The tubers are oblong-flattened or roundish-flattened; the ends are usually blunt. The skin is of a dull creamy-white color and is more or less netted. The sprouts are white.

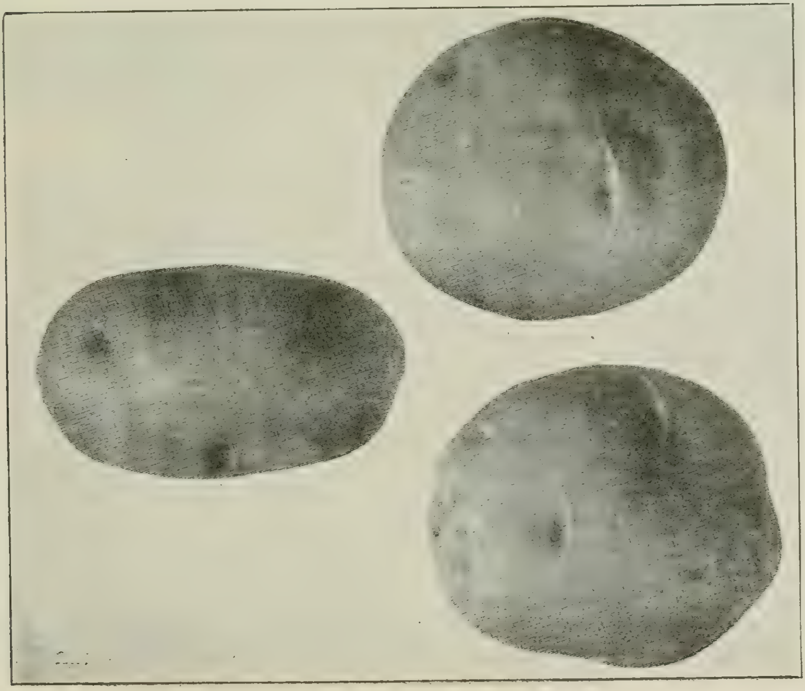


Fig. 6. Typical specimens of White Rurals.

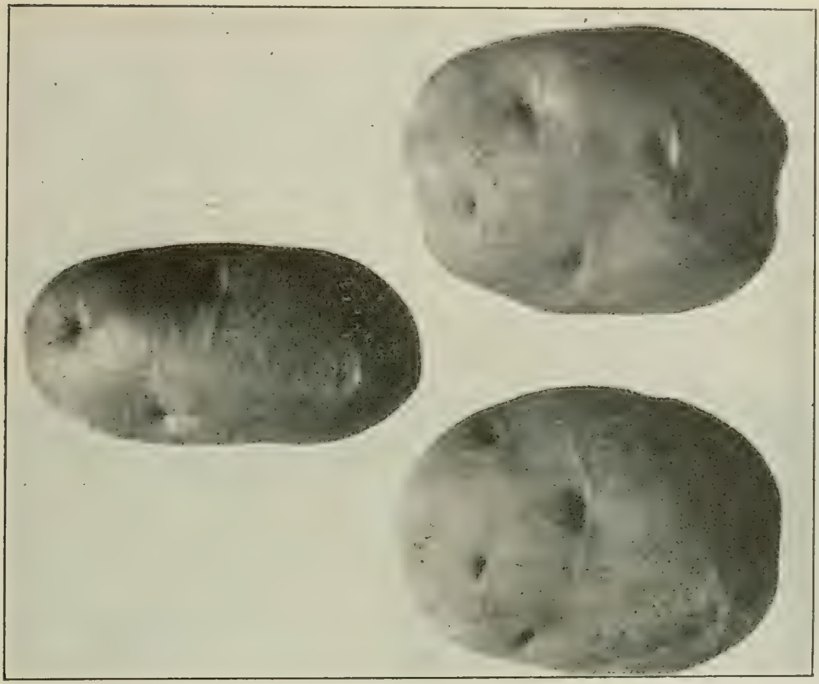


Fig. 7. The Green Mountain variety is characterized by having rather blunt seed and stem ends.

SEED SELECTION

Growers generally have paid little attention to the careful selection of seed potatoes. In many cases culls or unmarketable potatoes have been used for seed purposes. Continued indiscriminate planting of the screenings or small potatoes results in the production of poor yields, of inferior quality. Many potato diseases such as mosaic, leaf roll, etc., produce small potatoes. Growers should be sure that what small seed they use comes from strong, healthy and productive hills.

For seed purposes, potatoes should be free from varietal mixtures and diseases, and should come from vigorous, high yielding plants. In selecting seed potatoes from the bin, the grower cannot tell whether the stock selected came from good or poor hills.

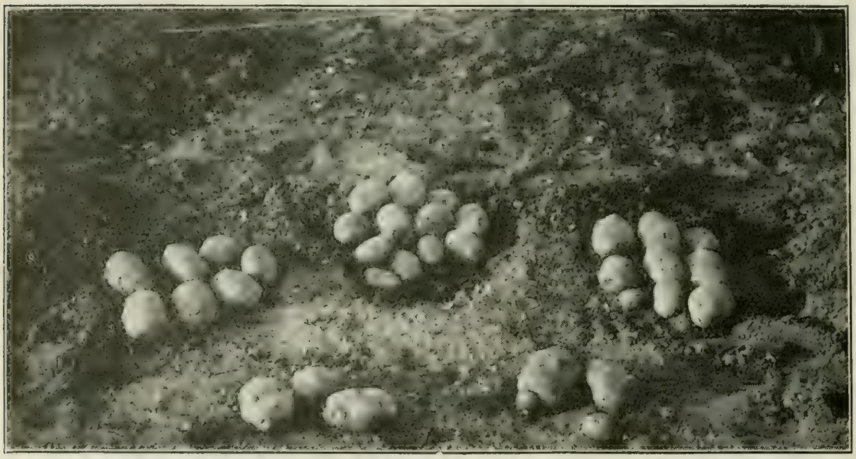


Fig. 8. Five hills of potatoes showing variation in yield and quality. Improve the yield and quality of the crop by selecting the best hills for seed purposes.

The hill selection method of obtaining good seed is one of the most effective and economical ways of increasing the yield and bettering the quality of the potato crop. A very satisfactory way to carry out this method is to set aside a portion of the field as a seed plot. The area of this plot will be determined mostly by the acreage of potatoes ordinarily grown. An area equal to about one-tenth that of the total acreage will usually prove sufficient. The seed plot is cultivated and sprayed the same as the regular potato field. During the growing season the seed plot is gone over several times, and all weak, diseased and off-type hills, including both vines and potatoes, are removed from the field. This process is termed "roguing." It is important that the last roguing be done shortly before the vines mature or before they are killed by frost, as some diseases such as Fusarium wilt, black leg, "giant hill," etc., may not show until late in the growing season. At harvest time the seed plot should be dug by hand, keeping the hills separate. Those hills that have approximately four or more uniform sized tubers of ideal type that average approximately six to twelve ounces in weight should be saved and planted the following year in a seed plot. It should be remembered that the number of potatoes a hill produces is determined largely by the number of stems in the hill. A productive single stem hill should produce four or more good tubers. A hill with two or more stems may produce six or more potatoes and yet not have as good yielding qualities as the one-stem hill that grows four tubers. After the best hills have been saved for the next year's seed plot, the poorest hills, that give low yields of poor quality potatoes, should be picked up and kept separate for eating purposes. Then the remaining hills are harvested and saved to plant the main crop the next year. It has been proved that if this method of selection is followed consistently, it will in a few years time give increased yields of twenty per cent or more, and that the quality of the potatoes will be improved.

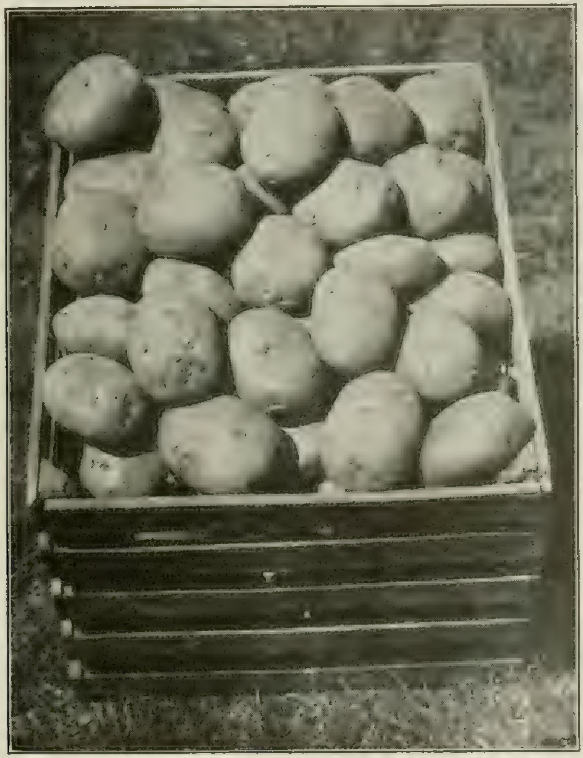


Fig. 9. A crate of choice seed potatoes of the Late Petoskey (Russet Rural) variety.

Seed potatoes should not be saved from those plants that have an exceptionally vigorous, upright habit of growth. This type of plant termed "giant hill" remains green very late in the season. It is quite immune to leaf-hopper and foilage disease injuries and is generally resistant to light frost. Potatoes from such plants produce poor yields of inferior quality.

Growers whose seed potatoes contain varietal mixture and diseases, and which are not giving satisfactory yields would do well to buy at least a few bushels of Michigan Certified Seed Potatoes and grow them in comparison with their own stock. The tests that were made with Michigan Certified Seed in 1921, in Michigan and in other states, showed that the certified seed gave an average increased yield of approximately 42 bushels per acre over seed with which it was compared.

The inspection and certification of seed potatoes in Michigan is conducted by the Michigan Potato Producers' Association in co-operation with the Michigan Agricultural College. Information concerning sources of the certified seed and detailed information on the inspection and certification work may be secured by writing to the Secretary of the Michigan Potato Producers' Association, East Lansing, Michigan.

Fig. 10. Harvesting a field of Certified seed potatoes in Schoolcraft County.

SEED TREATMENT

Control of Scab and Black Scurf (Rhizoctonia)

Seed potatoes should be carefully graded, and all ill-shaped, mechanically injured, and partially rotted tubers should be removed before the seed is put in the disinfecting solution. Potatoes should be comparatively free from dirt before they are treated.

Potatoes should be treated while they are dormant and before they are cut.

Soak the potatoes for 30 minutes in a solution of corrosive sublimate (bichloride of mercury), the strength of which is 4 ounces of corrosive sublimate to 30 gallons of water.

Dissolve the 4 ounces of corrosive sublimate crystals in 2 quarts or so of hot water, and then add it to the 30 gallons of unheated water.

Corrosive sublimate corrodes metals. It should be used in wooden vessels. A 50-gallon wooden barrel is a satisfactory container in which to soak the potatoes. By using two or more barrels, a large quantity of potatoes can be treated in a day.

Where 100 bushels or more of potatoes are to be treated, the work can be done more conveniently if a wooden trough or tank that will hold 8 or 12 potato crates is used. The potatoes in bushel crates are immersed in the corrosive sublimate solution. The tank can be made water tight by lining it with canvas and giving the canvas a coat or two of asphaltum paint.

The corrosive sublimate solution loses its strength with use, because the potatoes and dirt condense the chemical and take it out of solution. From one-tenth to one-fourth of the corrosive sublimate is removed with each batch of potatoes treated. The treating solution can be kept at the proper strength by adding corrosive sublimate from time to time. If the potatoes are placed in the solution loose and are comparatively free from dirt, add one ounce of corrosive sublimate dissolved in one quart of hot water for each 30 gallons of liquid after each second batch is treated.

If the potatoes are dirty and are treated in bags, add one ounce of corrosive sublimate for each 30 gallons of liquid after each batch is treated. When the treating solution gets very dirty, discard it and make up a fresh solution.

One pound of corrosive sublimate will treat from 30 to 60 bushels of potatoes.

Corrosive sublimate is a deadly internal **Poison.** Do not pour the solution where livestock or poultry can get at it, and do not use treated potatoes for eating purposes.

After the potatoes have been taken out of the solution they should be spread in a cool, shady place and allowed to dry thoroughly. It is a good plan to soak the bags or crates used for handling the treated seed in the corrosive sublimate solution in order to prevent any possible reinfection.

Green Sprouting

By being exposed to the light potatoes will develop stubby green sprouts that are generally an aid in securing good stands. Potatoes that are green sprouted come up more quickly and usually mature a crop a few days ahead of potatoes that are dormant when planted. The potatoes should be treated several weeks before planting time and put in a cool, well ventilated place where they will be exposed to light.

When potatoes are left in the cellar until planting time, they often develop long white sprouts, and the tubers become wilted. This wilting caused by loss of moisture lessens the vitality of the potato for seed purposes. Potatoes that are green sprouted in a cool place remain quite firm well up to planting time. Green sprouting gives the grower a chance to recognize and throw out potatoes that have weak sprouts.

Cutting the Seed

Smooth, well shaped potatoes that average five to twelve ounces in weight should be selected and cut so that each seed piece will contain one or more strong eyes. The pieces should be blocky and should weigh from one and one-quarter to two ounces. Potatoes that show discoloration in the flesh should not be used for seed purposes.

Where it is impossible to plant the seed as soon as it is cut, it should be spread out in a thin layer in a cool place that is well ventilated. Flowers of sulphur or gypsum can be sprinkled over it. The cut seed should be turned over once or twice a day until the cut surfaces are thoroughly dry. Cut seed when placed in bags or in piles will heat very quickly, and its sprouts will be seriously injured.

Whole seed will give better stands under adverse weather and soil conditions than will cut seed. Whole seed averaging four ounces in weight that was grown from vigorous, disease-free plants is quite satisfactory. Since many potato diseases, however, produce small tubers it is very important that the grower know the source of his seed stock.

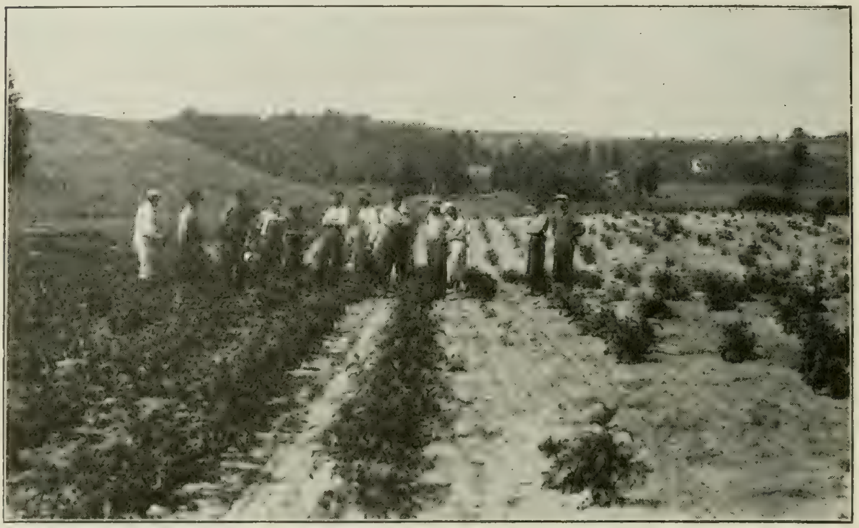


Fig. 12. The poor stand as shown in the rows on the right was due to the small cut seed pieces rotting in the soil. Rows on the left planted with whole seed show a good stand.

Generally the best results are secured where the seed is planted as fast as it is cut, provided it is placed in cool, moist soil. Freshly cut seed when put in a hot soil or cold, wet soil is likely to rot before the sprouts can take root. The moisture on the cut surfaces under unfavorable soil conditions aids in promoting the growth of vegetable rotting bacteria. In 1921 many potato fields in the state were complete failures due to freshly cut seed rotting in the hot soil.

PLANTING POTATOES.

Time of Planting

The time of planting varies according to the variety grown, and to the locality and season. Early varieties produce marketable potatoes in about 60 to 90 days from planting time. The late varieties require approximately 100 to 130 days to mature a crop.

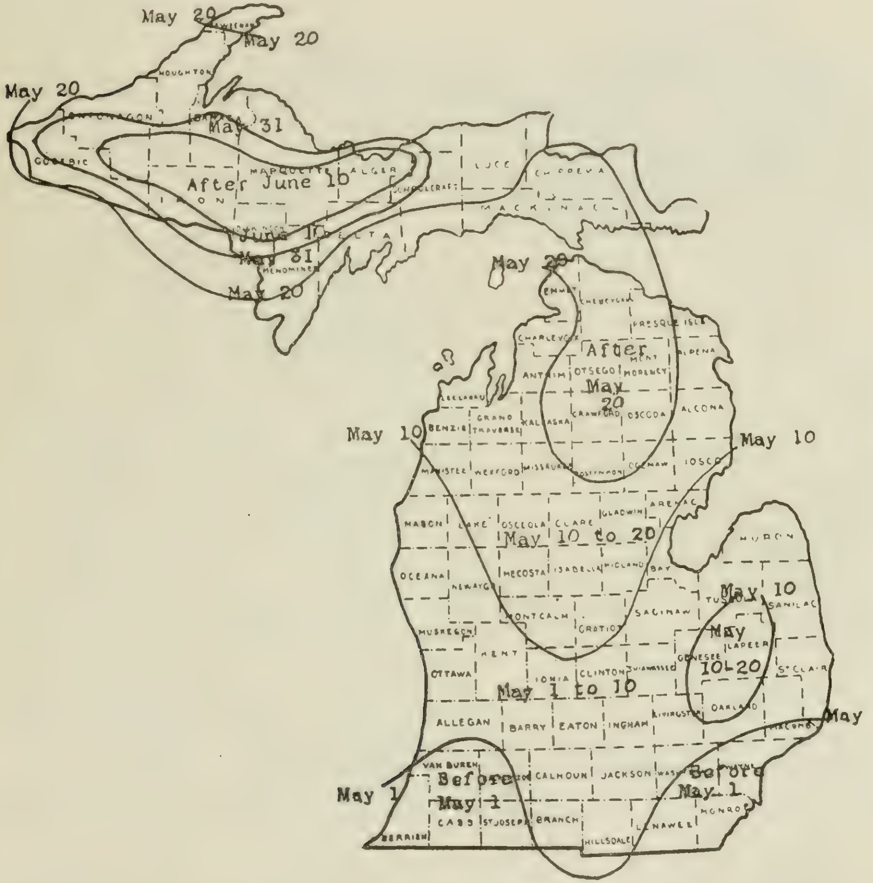


Fig. 13. Chart showing average date of last killing frosts in spring.

Early varieties are generally planted as soon in the spring as the soil can be fitted in good condition. If planted too early, the seed pieces may rot in the wet, cold soil, and the tops may be injured by late frosts. The early crop is often planted about two weeks before the average date of the last killing frost in the spring.

Late potatoes should be planted in time so that the crop will mature before the average date of the first killing frost in autumn. Planting time usually begins in late May, in Michigan, and continues to late June. The largest part of the crop is planted before the 15th of June.

In those sections of the state that have longer growing seasons than are required to mature the crop, the time of planting the late crop should be largely determined by the climatic conditions that can normally be expected.

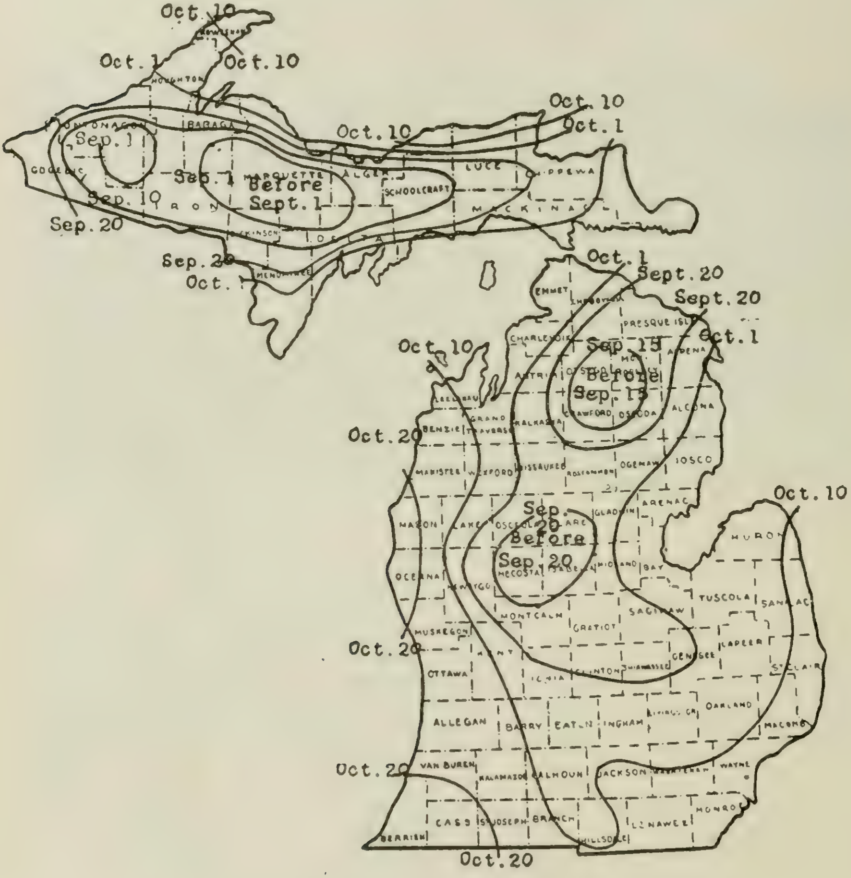


Fig. 14. Chart showing average date of first killing frost in autumn.

Many sections of the state are subject to periods of drought during July and the first half of August. The critical period in the life of the potato plant is when it is setting its tubers. If tubers set during a hot, dry spell, the yield is likely to be low. In many sections, late potatoes are usually planted about the middle of June so that they will be setting tubers during the latter part of August and first half of September, when temperature and moisture conditions are generally more favorable for potato growing.

Depth of Planting

The depth of planting will be governed mostly by the character of the soil, and by the time of planting. For the late crop on the lighter types of soil the sets are placed to a depth of 4 to 6 inches, while on heavy soils a depth of 3 to 4 inches is sufficient. In very early planting the depth should be less than in late planting because of colder soil and weather conditions.

It is important that the seed pieces be placed sufficiently deep to be in cool, moist soil and so that they will not be disturbed by subsequent tillage with a spike-tooth harrow or weeder.

Planting Distance

The natural fertility of the soil, together with its moisture-holding capacity, will determine largely the distance of planting. On fertile soils that are well supplied with humus, potatoes can be planted closer than they can on soils that are deficient in plant food and humus. Early varieties of potatoes are generally planted somewhat closer than late varieties, since the vine growth of the early kind is not usually as large as that of late varieties. High price of seed may act as a factor in causing a wider spacing of the plants.

On the lighter types of soils it is quite a common practice in this state to plant potatoes in check rows that are 36″ x 36″ apart. This method is extensively used by growers who plant with the hand planters and who dig the crop with forks. On land that is infested with quack grass or Canada thistles it is much easier to keep the field clean by cultivating both ways. The practice of planting in check rows is not generally recommended. When the plants are spaced so far apart they are likely to develop oversized, rough tubers that in many seasons are hollow. When soil conditions permit, it is better to plant the potatoes in drills, with the rows approximately 36 inches apart, and the hills 12 to 24 inches apart in the row, depending upon the fertility of the soil. The drill method of planting generally produces a larger yield of medium sized, marketable potatoes and reduces the amount of oversized tubers. In tests conducted in Wexford county on light soils where plots planted 36″ x 36″ were compared with plots planted 36″ x 18″, the closer planting gave an increased yield of 38 bushels per acre. The potatoes from the closer planting were also of much better market quality.

The amount of seed required to the acre depends upon the distance of planting and the size of the seed piece. With rows 36″ x 36″ apart, if seed pieces averaging one and one-half ounces are used, approximately 8 bushels of seed to the acre will be required. Approximately 15 bushels of seed cut to one and one-half ounce seed pieces will be needed to plant an acre when the rows are 36″ apart with the hills 18″ apart in the row.

Planting Tools

On land that is free from stumps and large stones, machine planters will prove very satisfactory. They will deposit the seed at a uniform depth and will cover it at once with moist soil so that it will not dry out. Where a grower plans to grow five acres or more of potatoes, he is usually warranted in buying a planting machine, which will enable him to plant four or five acres of potatoes a day.

There are two general types of machine planters. The one-man or picker type in which the seed is automatically picked up and dropped by forks that are attached to a revolving vertical disk, and the two-man or platform type of planter in which the seed pieces are fed onto a revolving platform. With this type of machine a man or boy sits on the back of the machine and sees that each pocket of the revolving platform contains one seed piece. The two-man type of planter, if properly handled, will make less than one per cent of misses. The picker or one-man type is likely to make five to twenty per cent misses, and for this reason the two-man type of machine is generally preferred.

Most mechanical planters have fertilizer attachments that distribute the fertilizer in the bottom of the furrow and cover it with soil so that the seed pieces do not come in contact with it.

The hand planter or "jabber" is used extensively in the northern counties. It is particularly useful when planting potatoes on new land. When planting with the hand planter the rows are generally marked out both ways with a marker, and the potatoes are planted at the intersection of the marks. A man can plant about one acre of potatoes a day with a hand planter if the soil is mellow and well prepared. If the operator takes care to plant the sets deep enough so that they will be in moist soil, very effective work can be done with a planter of this type.

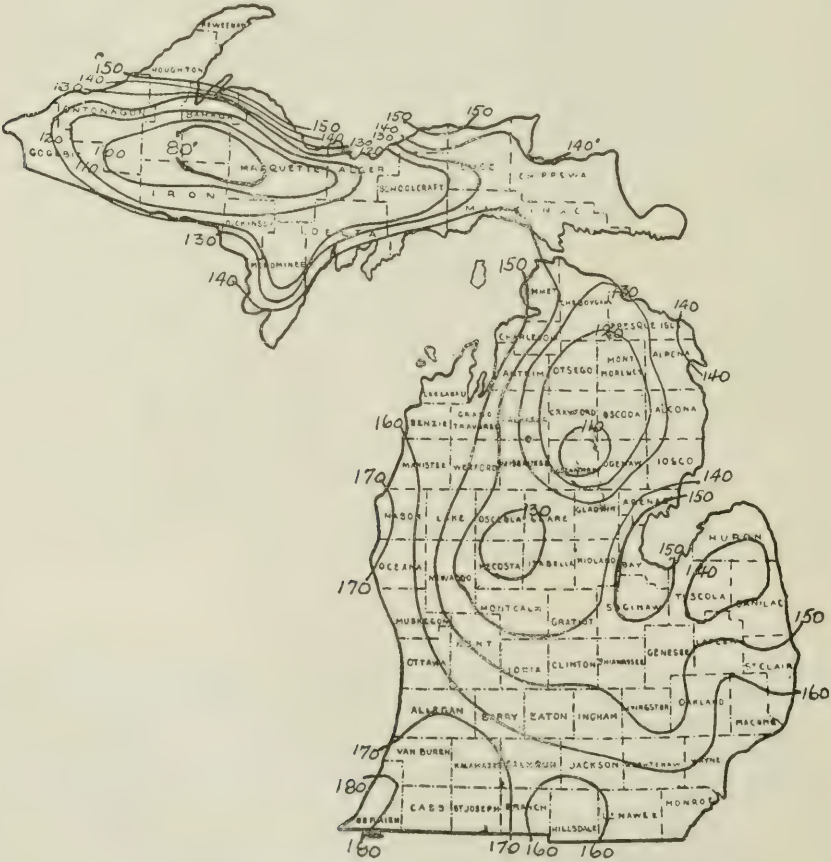


Fig. 15. Chart showing length of growing season in days.

If potatoes are planted by hand, a good implement with which to open the furrows is a wing shovel plow. Such a plow makes the furrows narrow at the bottom and the seed pieces can be planted in a straight line. The furrows should be opened just before the seed is dropped and should be covered at once, so as to keep the soil cool and moist and to prevent the seed pieces from being exposed to the sun and wind. The seed may be covered with a hoe or with a shovel plow.

CULTIVATION

Shortly after the field is planted it should be gone over with a spike-tooth harrow or a drag, lengthwise of the rows. This operation should be repeated several times before the plants get well above the ground, so that weeds and grass will be killed and a soil mulch maintained.

When the plants are large enough so that the rows can be easily seen, a cultivator should be used. The first cultivation should be deep and quite close to the plants. Frequent cultivations must be given to keep down weeds and grass and to provide a soil mulch. Each subsequent cultivation should be shallower and farther away from the plants than the one preceding it. By the time the plants are eight to twelve inches high, their roots extend well into the middle of the rows, and deep cultivation will cut many of the roots and reduce the yield. Cultivation should ordinarily cease after the plants are in full bloom and the tubers have set.

The riding or sulky cultivators are often preferred over the one-horse walking cultivators since they can be regulated to work at a uniform depth, and generally do less damage to the potato roots than the walking type of cultivator.

On light soil that is comparatively free from thistles, etc., narrow or peg-teeth are generally used. On heavier soils and on those in which there are serious weeds, wider teeth should be used.

On soils that are well drained, level cultivation is usually preferable to ridging or hilling the potatoes. The ridging method is used to some extent in the Upper Peninsula where there is ample rainfall, but in sections where drought is of common occurance soil that is ridged dries out more quickly than soil that is kept level, with the result that the yield is often greatly reduced.

SPRAYING

The green leaves of the potato plant are largely responsible for the development of the tubers, for it is in the green leaves that starch and other elaborate food substances that go into the making of the tubers are made. In a large measure, the yield of potatoes is limited by the amount of healthy green leaf area that the plant possesses. If insects or fungous diseases destroy even a small portion of the green leaves, the yield of potatoes will be materially reduced.

The green leaf area can be saved from the ravages of insects and diseases that attack the foliage by spraying the plants thoroughly with arsenicals, bordeaux mixture, etc.

Time and Number of Applications

The first spray application should be made when the plants are about four inches high. Other applications should follow at intervals of approximately ten days or two weeks throughout the growing season. The frequency of the applications will be determined largely by weather conditions and by the prevalence of injurious insects. In rainy seasons it may be necessary to spray more often than at the intervals mentioned, since the bordeaux mixture may be washed off the leaves by frequent rains; also, the late blight disease is more likely to develop during periods of wet, muggy weather. Serious outbreaks of insects would also warrant more frequent applications.

Usually at least five applications will be required to control insect pests and fungous diseases.

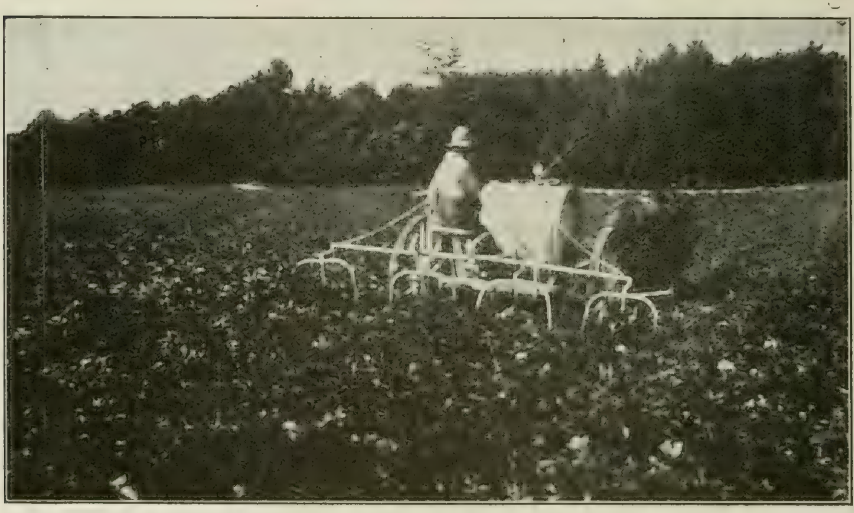


Fig. 16. Spraying should be continued late in the season. Very little injury is done by the wheels of the machine.

Spraying Machine Essentials

The spray machine used should be capable of maintaining a pressure of at least 170 pounds, so that the spray material will be thrown from the nozzles in the form of a dense mist. When the plants get large, approximately 100 gallons of spray material will be required to the acre. When the plants are small, 50 gallons or so will be sufficient. The machine should be equipped with two or three nozzles to the row, placed so that the spray will reach both the under and upper surfaces of the leaves. It is very essential that the lower surfaces of the leaves be protected with the spray, since most insects and fungous diseases begin their attacks on the under sides of the leaves.

The machine must have an efficient mechanical agitator, which will keep the spray mixture thoroughly stirred.

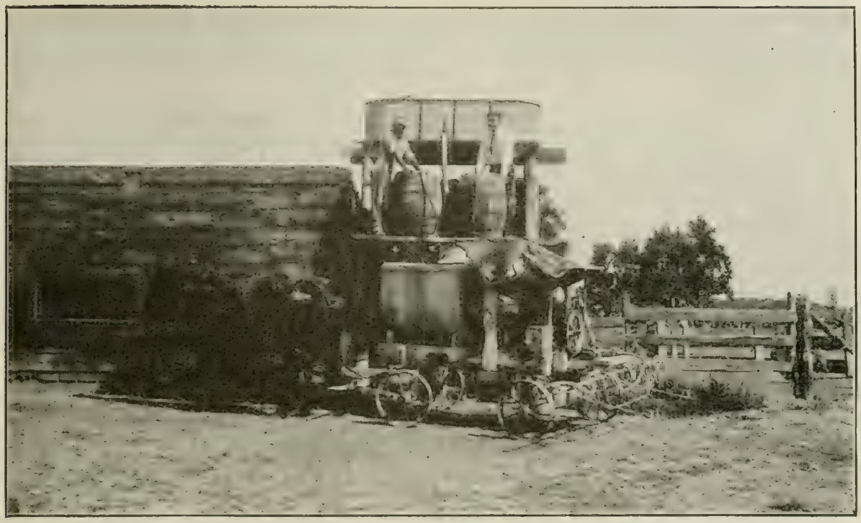


Fig. 17. The elevated mixing platform lessens the labor of filling the spray tank.

Spray Materials to Use

In addition to arsenical poisons for the control of leaf chewing insects, every spray application should contain bordeaux mixture (4-4-50) for the control of hopperburn, early blight, and late blight.

Hopperburn, also called tipburn, is caused by leafhoppers. They are pale green insects that live mostly on the under sides of the leaves where they feed by sucking the plant juice, causing the leaves to curl upward and turn black at the tips and margins. Leafhoppers appear in potato fields about the middle of June and breed in them throughout the season. Bordeaux mixture aids in warding off serious attacks of the leafhoppers and helps to keep the plants green. Leafhopper injury is most pronounced late in the season. It is very important that the bordeaux applications be continued until the end of the growing season. The small amount of injury to the vines caused by the wheels of the spray machine is of little consequence. Do not cease spraying because the vines are rank.

The leafhopper is one of the most serious pests that attacks the potato. It is largely responsible for the average low yields that are secured in this state. In 1921 many potato fields were dying from leafhopper injury or hopperburn during August and September, right at the time when they should have been in a healthy, green condition.

Hopperburn is usually most severe in hot, dry weather. Bordeaux mixture does not kill the leafhopper but it does act as a repellant. It has been found that in hot, dry weather the bordeaux mixture acts as a stimulant to the potato plants, and in a small degree counteracts the effects of adverse weather conditions.

Early blight is a fungous disease that is most serious during periods of hot, dry weather. It produces target-like markings on the leaves and reduces the yield of tubers.

Late Blight causes rotting of the leaves and stems and may also cause a rotting of the tubers. The attacks occur during cool, wet seasons. Thorough spraying with bordeaux mixture before these diseases appear is essential for their control.

Colorado Potato Beetle: This insect causes serious losses every year. Growers should secure poisons early in the season, and have everything ready so that spraying can be done at the first appearance of the young bugs. If spraying is delayed until the bugs are five or six days old, a poison spray of much greater strength will be required.

Add one to one and one-half pounds of calcium arsenate to every 50 gallons of bordeaux mixture. Before the calcium arsenate is added to the bordeaux mixture it should be mixed with a small quantity of water until it is free from lumps and is of the consistency of thin cream. While calcium arsenate is recommended in preference to arsenate of lead powder, if the latter is used it should be combined with the bordeaux at the rate of one and one-half to two pounds to 50 gallons. While paris green is not to be preferred, if used, it should be combined with the bordeaux at the rate of one-half to one pound to 50 gallons of the mixture.*

Flea Beetles: These small black insects often damage the crop severely by riddling the leaves with small holes. Bordeaux mixture and calcium arsenate or arsenate of lead will repel their a ttacks.

Aphids or lice suck the juice from the under sides of the leaves. Add one-half pint of forty per cent nicotine sulphate solution to each 50 gallons of bordeaux mixture and apply the spray so that it will actually hit the lice. Spray applications containing nicotine sulphate should be applied as soon as possible after the lice are first noticed in the field.

Tomato Worms: These insects can be controlled when they are small with the same poisons that are used for the Colorado Potato Beetle. If spraying is delayed until the worms are half grown, add two and one-half pounds of calcium arsenate to every 50 gallons of bordeaux.

How to Make Bordeaux Mixture

Bordeaux mixture (4-4-50) is made as follows: Dissolve 4 pounds of copper sulphate (blue vitrol) crystals in a wooden barrel containing 25 gallons of water. Put the crystals in a burlap bag and suspend the bag so that the crystals are just under the surface of the water. It will require several hours for them to dissolve.

In a separate barrel, slake 4 pounds of stone lime by adding small quantities of water to it, so that the lime crumbles into a fine powder. Gradually add more water until the lime is of the consistency of thin cream. Then add water to make 25 gallons. When stone lime is not available, hydrated lime may be used in the proportion of 6 pounds of lime to 4 pounds of copper sulphate to 50 gallons of water.

Pour the copper sulphate solution (25 gallons) and the lime solution (25 gallons) together through a fine meshed strainer into the spray tank and apply it to the potatoes at once.

Where several acres of potatoes are to be sprayed, stock solutions of copper sulphate and lime should be made. Dissolve 50 pounds of copper sulphate in

---

*Kedzie mixture or arsenite of calcium is recommended by Prof. R. H. Pettit, Entomologist, Michigan Agricultural College, for the control of the Colorado Potato Beetle and the flea beetle. See Michigan Agricultural Experiment Station Special Bulletin No. 114.

50 gallons of water. In a separate vessel slake 50 pounds of stone lime or 75 pounds of hydrated lime and add water to make 50 gallons. These stock solutions will keep in good condition for several weeks if they are kept covered to prevent evaporation of water, and will be sufficient to make 625 gallons of bordeaux mixture.

It will require approximately 100 gallons of bordeaux mixture per acre for each application. Growers should estimate the number of pounds of copper sulphate and lime that they will require and should secure it early in the season.

Stir each of the stock solutions vigorously. Fill the spray tank (100 gallon tank) half full of water. Pour into the spray tank 8 gallons of the lime solution and stir thoroughly. Add water until the tank is about three-fourths full. Then add 8 gallons of the copper sulphate solution. Stir thoroughly and add enough water to fill the tank. *Never pour together the strong stock solutions.*

Every effort should be made to keep splinters, dirt, etc., out of the spray tank. Use a hardwood stirring stick and remove all loose splinters from inside the stock solution barrels. All material put in the spray tank should be poured into it through a fine meshed sieve.

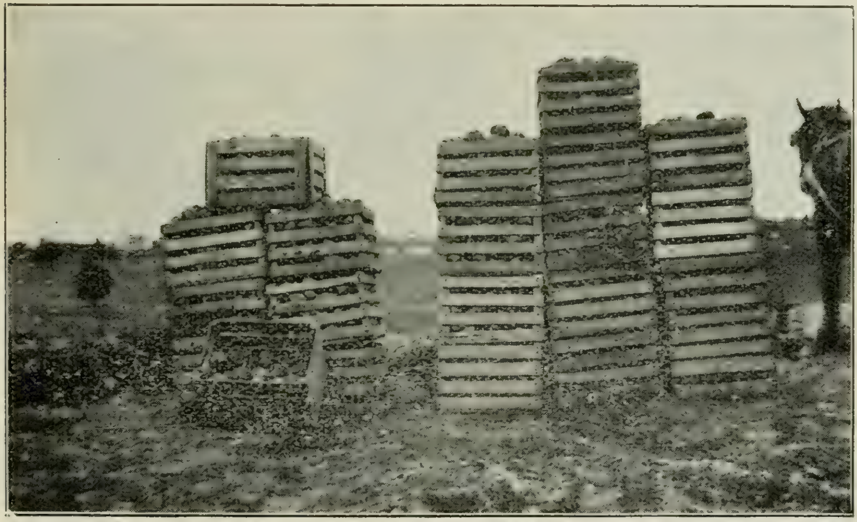


Fig. 18. Results of spraying with bordeaux mixture. Yield from unsprayed plot 176 bu. per acre. Yield from plot sprayed with bordeaux 319 bu. per acre. Photo by K. K. Vining.

HARVESTING

Potatoes are harvested after the vines mature, or after they are killed by frost. The bulk of the crop in this state is harvested during the month of October.

If possible potatoes should be dug during cool, clear weather and the soil should be comparatively dry. After the potatoes are dug they should be left on the ground for a few hours so that they will dry and their skins toughen.

Much of the crop in this state is dug with forks; one man can dig about one-eighth to one-half acre a day. On fields that are free from stumps and large stones, the mechanical diggers of the elevator type will shorten the harvesting period and will reduce much of the laborious work. With a good digging machine a man can dig three to six acres a day.

Every effort should be made to harvest the crop so that the percentage of mechanically injured potatoes is reduced. One of the most common criticisms on the market against Michigan potatoes is the large percentage of potatoes that are fork punctured, cut, or bruised. Such injuries favor the development of soft and dry rots in storage.

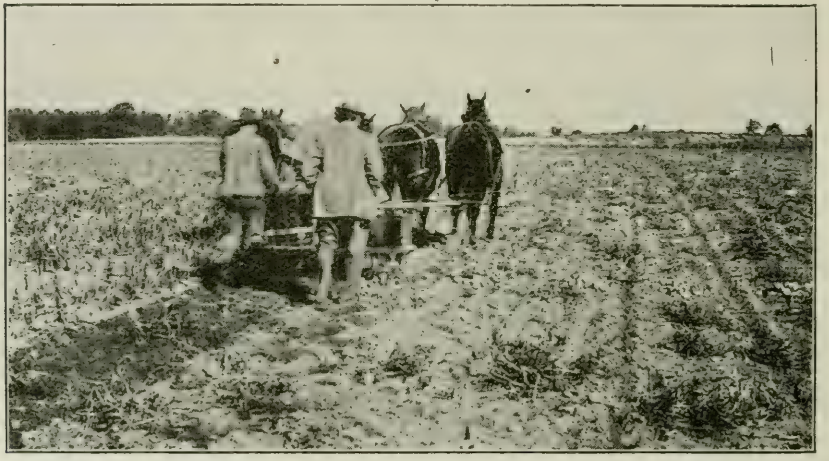


Fig. 19. A digging machine shortens the harvest period and lessens the laborious work.

More attention should be paid to grading in the field. Ill-shaped, cut or fork-punctured potatoes should not be picked up with the good stock. Potatoes are generally picked up in bushel crates and are hauled to market or to storage cellars. Hauling the potatoes to storage in crates instead of in bulk will lessen much of the mechanically injured stock.

If potatoes are quite immature when they are dug, it is a good plan to place them in piles of 40 to 50 bushels and cover them with straw to prevent frost injury. After a few days the potatoes will have gone through a curing process and will keep better when placed in storage.

Fields that have been injured by late blight should not be dug for a week or more after the vines have died. This delay of harvesting will allow many of the infected tubers to rot in the soil instead of in storage and will lessen the amount of storage rot.

GRADING

The careful grading of potatoes as to size and quality is essential. Potatoes of high quality that are carefully graded generally bring a premium over potatoes that are not well graded. There is always a good demand for the best quality stock.

It is a good plan to grade potatoes over a mechanical sorter before they are placed in storage. This process removes much of the dirt from the potatoes and separates the culls from the marketable stock. The mechanical sorter will grade potatoes as to size, but the task of removing ill-shaped, scabby or mechanically injured potatoes rests with the operator.

Not only is it important that potatoes be graded, but it is equally as important that the grades be standardized, so that buyers and sellers of potatoes will have a common basis on which to do business.

The following standard grades are recommended by the U. S. Department of Agriculture. (Department Circular 238, July, 1922.)

U. S. No. 1

U. S. No. 1 shall consist of potatoes of similar varietal characteristics which are not badly mis-shapen, which are free from freezing injury and soft rot, and from damage caused by dirt or other foreign matter, sunburn, second growth, growth cracks, hollow-heart, cuts, scab, blight, dry rot, disease insects, or mechanical or other means.

The diameter of potatoes of round varieties shall not be less than one and seven-eighths inches, and of potatoes of long varieties, one and three-fourths inches.

In order to allow for variations incident to proper grading and handling, not more than five per cent, by weight, of any lot may be below the prescribed size, and, in addition, not more than six per cent. by weight, may be below the remaining requirements of this grade, but not to exceed one-third of this six per cent tolerance shall be allowed for potatoes affected by soft rot.

U. S. No. 1 Small

U. S. No. 1 Small shall consist of potatoes ranging in size from one and one-half inches to one and seven-eighths inches in diameter but meeting all the other requirements of U. S. No. 1.

In order to allow for variations incident to proper grading and handling not more than twenty-five per cent, by weight, of any lot may vary from the prescribed size, but not to exceed one-fifth of this tolerance shall be allowed for potatoes under one and one-half inches in diameter. In addition not more than six per cent, by weight, may be below the remaining requirements of this grade, but not to exceed one-third of this six per cent tolerance shall be allowed for potatoes affected by soft rot.

U. S. No. 2

U. S. No. 2 shall consist of potatoes of similar varietal characteristics which are free from freezing injury and soft rot, and from serious damage caused by sunburn, cuts, scab, blight, dry rot, disease, insects, or mechanical or other means.

The diameter of potatoes of this grade shall be not less than one and one-half inches.

In order to allow for variations incident to proper grading and handling, not more than five per cent, by weight, of any lot may be below the prescribed size, and, in addition, not more than six per cent, by weight, may be below the remaining requirements of this grade, but not to exceed one-third of this six per cent tolerance shall be allowed for potatoes affected by soft rot.

U. S. Fancy No. 1

U. S. Fancy No. 1 shall consist of potatoes of one variety which are mature, bright, well shaped, free from freezing injury, soft rot, dirt or other foreign matter, sunburn, second growth, growth cracks, hollow-heart, cuts, scab, blight, dry rot, disease, insect or mechanical injury, and other defects. The range in size shall be stated in terms of minimum and maximum diameters or weight following the grade name, but in no case shall the diameter be less than two inches.†

In order to allow for variations incident to proper grading and handling, not more than five per cent, by weight, of any lot may vary from the range and size stated, and, in addition, not more than six per cent, by weight, of any lot may be below the remaining requirements of this grade, but not to exceed one-third of this six per cent tolerance shall be allowed for potatoes affected by soft rot.

DEFINITION OF TERMS

As used in these grades:

"Mature" means that the outer skin (epidermis) does not loosen or "feather" readily during the ordinary methods of handling.

"Bright" means free from dirt or other foreign matter, and from damage or discoloration from any cause, so that the outer skin (epidermis) has the attractive color normal for the variety.

"Well shaped" means the normal, typical shape for the variety in the district where grown, and free from pointed, dumb-bell shaped, excessively elongated, and other ill-formed potatoes.

"Diameter" means the greatest dimension at right angles to the longitudinal axis.

"Free from damage" means that the appearance shall not be injured to any extent readily apparent upon casual examination of the lot, and that any damage from the causes mentioned can be removed in the ordinary process of preparation for use without appreciable waste in addition to that which would occur if the potato were perfect. Loss of outer skin (epidermis) shall not be considered as an injury to the appearance.

"Badly mis-shapen" means of such shape as to cause appreciable waste in the ordinary process of preparation for use in addition to that which would occur if the potato were perfect.

"Free from serious damage" means that any damage from the causes mentioned can be removed by the ordinary process of preparation for use without a waste of ten per cent or more, by weight. in addition to that which would occur if the potato were perfect.

---

†Such statements as the following will be considered as meeting the requirements: "U. S. Grade Fancy, 2 to 3½ inches," "U. S. Grade Fancy, 10 to 16 oz.," "U. S. Grade Fancy, 2 inches and larger," "U. S. Grade Fancy, 10 oz. or larger."

STORAGE

Potatoes that are to be stored should be sound, dry, and quite free from dirt. The temperature of the storage cellar must be high enough to protect the potatoes from frost and low enough to hold the tubers dormant. A temperature of 35° to 40° F. keeps the potatoes in good condition.

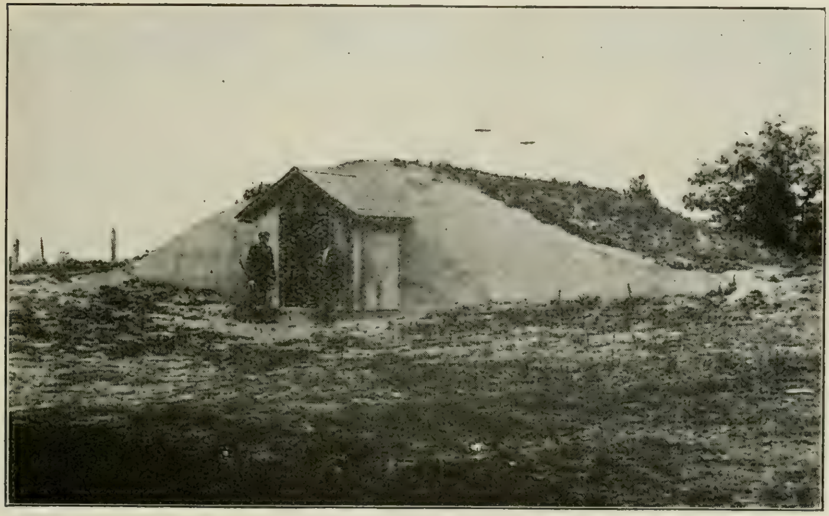


Fig. 20. A satisfactory farm storage cellar. Cold air is taken in at the bottom of the cellar by means of a 12 inch pipe. The moist heated air is removed through the ventilator pipes in the roof.

Potatoes are constantly giving out moisture and various gasses, and there must be an adequate system of ventilation that will carry off the foul, moist air and replace it with fresh air. When potatoes are first put in storage they go through a sweating process, and unless the temperature of the storage house is lowered quickly and plenty of fresh air is admitted the potatoes are likely to heat and rot. The temperature of the storage house can be lowered by keeping the windows and doors open on cool nights and closing them early in the morning.

Potatoes should not be stored in piles more than **6 feet deep** unless provision is made for aerating the piles. Potatoes must have a constant supply of oxygen. In large deep piles, sufficient fresh air cannot get to the tubers, and much damage is caused by the potatoes becoming overheated. Aeration of large piles of potatoes can be provided for by placing ventilated division walls throughout the pile at intervals of 6 or 8 feet as the potatoes are put in the bin. These division walls may be made from 2″ x 6″ uprights with 1″ x 4″ strips nailed on either edge. A one inch space should be left between each strip.

Potatoes are injured for food purposes if they are exposed to light. All light should be excluded from the storage cellar.

Potatoes can be stored in pits quite satisfactorily. The pits should be located on high, well drained soil and should be about 8 to 12 inches deep. The potatoes should be placed in long narrow piles and should be piled in a ridge of inverted V shape.

Ventilation may be provided by putting in wooden flues that extend from near the bottom of the pit to well above the covering of the pit. In freezing weather, the top openings of the ventilators must be closed.

During the first few weeks of the storage, while the weather is mild, the potatoes should be covered with a layer of straw and only sufficient soil to exclude the light and frost. As the weather grows colder more soil should be added. Before freezing weather occurs an additional heavy layer of straw and another layer of soil should be added. Each layer of straw should be well packed and should be 8 inches or more thick. Each layer of soil should be from 6 to 8 inches deep. After the outer layer of soil has frozen the entire pit may be covered with a layer of coarse stable manure.

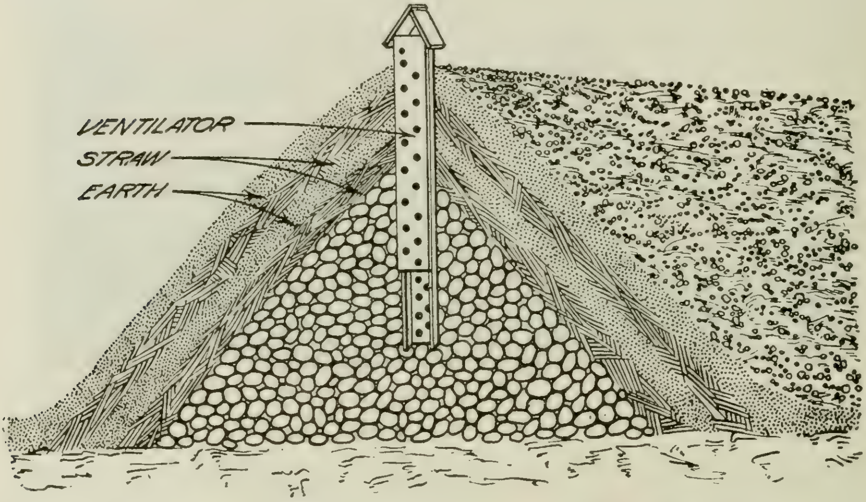


Fig. 21. Cross section of a potato pit. (U. S. D. A. Farmers Bul. 847.)

PRUNING FRUIT TREES

Special Bulletin No. 118

BY ROY E. MARSHALL

Most fruit growers will agree that tree growth and fruit production are regulated to a considerable extent by pruning practices, but there is much confusion as to the amount and kind of pruning that should be employed to give the desired results. Experiment Station investigators are gradually working out various phases of the pruning problem, but it will probably be many years before definite rules can be formulated relative to the training and pruning of all kinds and types of fruit trees.

Yet, while these problems are being solved, trees must be pruned. It is the main purpose of this bulletin to present some of the underlying principles which the fruit grower should constantly keep in mind, and to show how these principles may be applied to such trees as are commonly found in Michigan.

SOME GENERAL PRINCIPLES AND PRACTICES

Throughout the discussion of pruning practices certain terms are used more or less frequently, and it it well that an understanding be had of these, together with the general principles involved. Again, certain practices are applicable, in a general way, to all kinds of deciduous fruit trees, and these may be briefly discussed before taking up more detailed consideration of the handling of specific kinds of fruit trees.

Thinning—The removal of an entire branch, limb, twig or spur is referred to as thinning or "thinning out." Thinning results in a less crowded condition throughout the tree, and it usually permits a greater amount of light and a freer circulation of air in the interior portions. This kind of pruning generally encourages the formation of fruit spurs and discourages the development of lengthy side branches or laterals. It favors the development of an extensive fruiting system, but continued thinning with some kinds and varieties of fruits eventually leads to the formation of wide-spreading or rangy trees that are expensive to handle and that are unable to carry their crops without artificial supports.

Heading—When the tip or any larger portion of a branch is removed, the process is known as heading or "heading back." This type of pruning is practiced when branches are growing out of bounds; when one part of the tree is growing more rapidly in proportion to the tree as a whole than is desired; to encourage the development of the framework branches of the tree at such points as they are desired, and to avoid a rangy type of growth. The heading back of a vigorous shoot usually results in the formation of several strong-growing lateral shoots and few fruit spurs the succeeding year. Hence, it promotes the formation of a compact head. In other words, heading back has more to do with the development of form of tree than with the development of a fruiting system, and is practiced to a greater extent with young trees than with those in bearing. Heavily headed back young trees should not be expected to attain greater size than those headed lightly or not at all—in fact, if continued for several years, the gross effect is an undersized tree, as well as one late in coming into fruit production.

This division between thinning and heading is somewhat artificial. In other words, a single pruning cut may result in a thinning out as well as a cutting back. This is frequently the case when three- or four-year-old wood is being removed from peach trees and the cuts are made close to a lateral of the former parent branch.

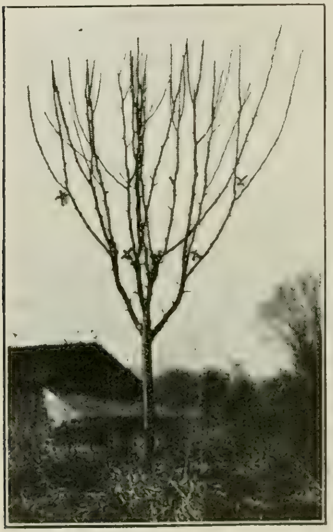


FIGURE 1. Equal heading back of all branches results in Y-shaped crotches such as are shown at X and throughout this apple tree. A tree pruned like this develops a number of growths from buds near the ends of the remaining branches and heavy thinning must follow the next year. Neither a strong tree nor early bearing result.

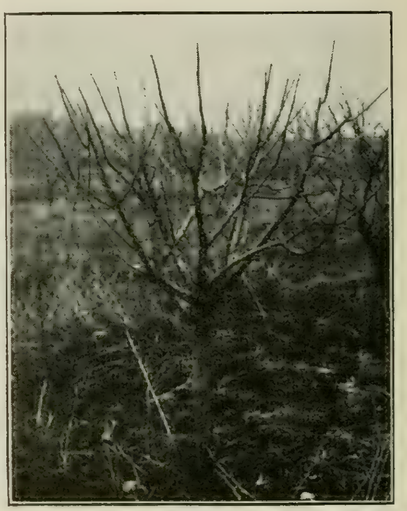


FIGURE 2. A four-year-old plum tree of the European group which has been headed back entirely too much and in which weak crotches are encouraged to form by equal cutting back of branches arising from a common point. This tree is a very good illustration of the open-center type of training.

Heading Back May Maintain or Destroy Balance Between Branches—Two branches that have made practically the same amount of growth are often found growing from a common point. If left unpruned or if headed back to the same length, the amount of growth from each the following year will be approximately equal. If one branch is cut several inches shorter than the other, the longer one will give rise to more growth the following years, and eventually the shorter one will become a side branch of the longer, as naturally occurs if one branch is longer than the other and no pruning takes place. Thus, equal cutting back of branches arising from a common point results in equal growth, and unequal cutting back results in unequal growth. Furthermore, when two branches of equal size emerge from a common place in such a way as to form a sharp "Y," a weak crotch results unless steps are taken to strengthen it. Equal cutting back of these two branches will not better the condition, but unequal cutting back, leaving one considerably longer than the other, will encourage the longer one to become a leader or main branch, and the other will eventually become a lateral or side branch. The crotch is strengthened and splitting in later years is avoided.

Long Pruning—Recently the attention of some fruit growers has been directed to a kind of pruning, very popular in California, known as "long pruning," and it may be well to state briefly the meaning of this term. Pruning as commonly practiced on the Pacific Coast, until quite recently, consisted of some thinning-out and a very heavy heading back (removal of 50 to 75 per cent of each new branch) of the new growth each year. This resulted in devotion by the trees of too large a part of their energies to the growth of long shoots and not enough to fruit production, and the fruiting wood on the interior portions of the trees was often shaded out by the dense

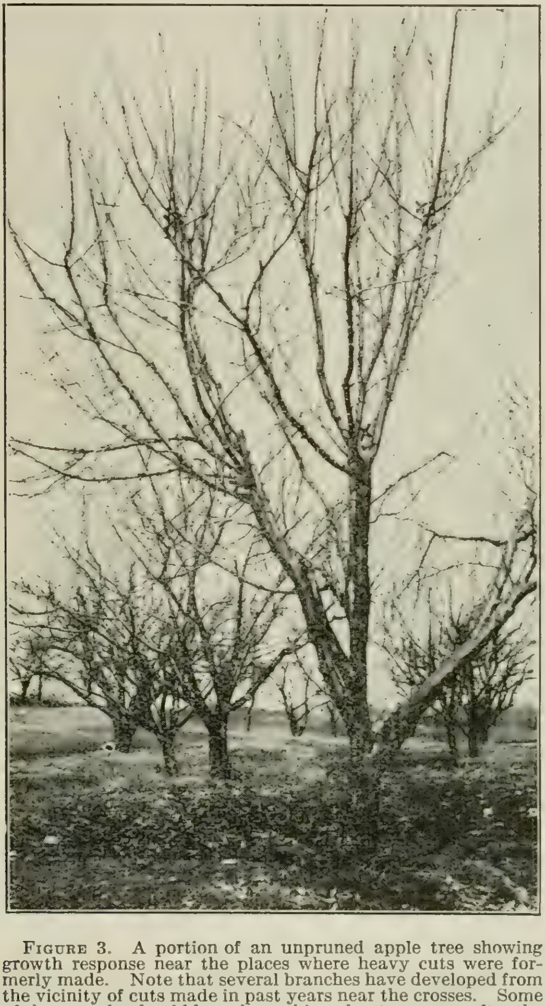


FIGURE 3. A portion of an unpruned apple tree showing growth response near the places where heavy cuts were formerly made. Note that several branches have developed from the vicinity of cuts made in past years near the crosses. Some of the growths should have been thinned out one year after the heavy heading.

top. Fruit growers have found that they can reduce this excessive wood growth and increase the fruitfulness of their trees by practicing a "thinning-out," and they thus discontinue the former severe "heading." Since the new growth is left without heading, the result is a tree very different in appearance from the former heavily cut-back one, and hence the term "long-pruning."

Results are Localized—Generally, the greatest growth response takes place in the immediate vicinity of a pruning cut. This is noticeable where a large branch has been removed, resulting in the formation of numerous watersprouts near the point of removal. In like manner, if a branch or shoot is cut back, a few laterals (side branches) will usually develop near the end of the headed-back branch, although some response may be noted some distance away. The removal of a branch has comparatively little direct effect on the tree as a whole. If, then, it is desirable to renew vegetative growth throughout the tree, the cutting must be distributed throughout the entire tree. Work confined to the outer parts of the tree will give direct response in those parts, but will generally indirectly affect the central parts by admitting more light and permitting a freer circulation of air. The careful pruner should keep these facts in mind in all pruning practices.

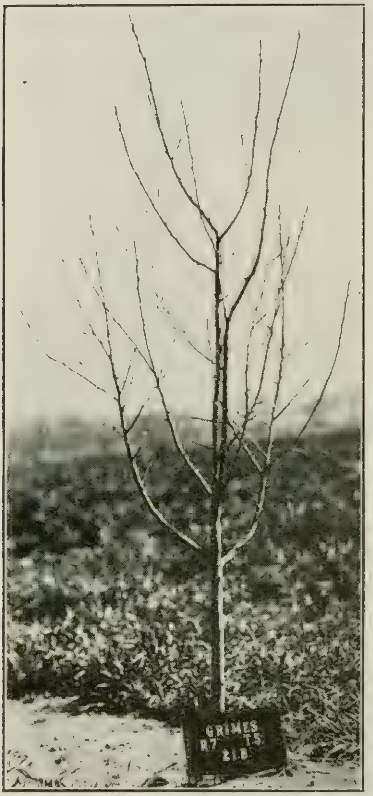


FIGURE 4. Such fruit spurs and short growths as are seen in the interior of this three-year-old Grimes Golden should not be removed as they are usually productive of the first fruits and they enable the tree to carry an evenly distributed load of fruit. This tree has had very light pruning since planting.

Conservation of Fruiting Wood—There is a strong tendency among pruners to remove all the fruit spurs and short shoots from the young trees, especially from the scaffold branches, as they are thought to be of no use. However, experience shows that, if allowed to remain, these are productive of the first fruit of the tree. If they are removed, the tree will not come into early bearing. Some pruners think that these small twigs will only be in the way in later years. These fruiting branches seldom reach a length of more than a few inches, and if they do they may be shortened. Even if some are broken off from time to time, it will certainly pay well to leave and preserve a liberal supply of them as long as possible.

How to Remove a Branch—So much emphasis has been placed by many writers upon right and wrong methods of removing branches that it would seem unnecessary to mention these again, but some growers are still very careless in this operation. The wound resulting from the removal of a branch will heal much more rapidly if the cut is made close to and almost parallel with the main stem. If removed even a slight distance beyond the parent branch, the result is a slow healing wound. If a stub is left, it usually dies and heart rot eventually develops in the parent branch. If is often advisable first to saw in for a short distance on the under side of large branches so as to prevent the splitting down and peeling of bark from the parent branch when the branch is nearly sawed through.

Time of Year for Pruning—Pruning is ordinarily done during the dormant season. Slight preference should be given to that done in late winter or early spring because the wounds heal more readily; but if all pruning is left until such a time, the work may not be completed because of the rush of other farm practices in early spring. Consequently, any favorable weather, after the dropping of the foliage in the fall and before the opening of the buds in spring, may be utilized for pruning. If one has a large acreage, he should start work in the older apple and pear trees during the early winter, and reserve the stone fruit and younger trees for late winter and spring pruning. It is believed that pruning done during any weather that is suitable for the pruner will result in no ill effects. However, it is possible that heart rot, die-back, bruising, splitting, etc., may result from pruning frozen wood.

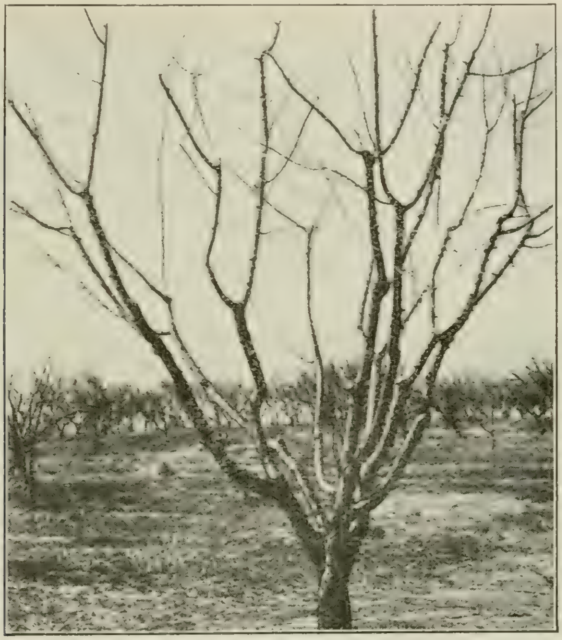


FIGURE 5. The fruit spurs and other growths have been removed from the interior and lower portions of this apple tree, hence the opportunity for early fruit production has been sacrificed and the bearing capacity of the tree has been materially decreased. Again, an originally low-headed tree has in reality become high headed.

Summer Pruning has received much attention from professional horticulturists, but the results have been rather confusing to the average fruit grower. While judicious summer pruning may result in the saving of a year or more in building the framework of the young tree and in stimulating fruit bud formation in some cases, the average grower should refrain from employing such practices until a better understanding of the matter is reached.

However, watersprouts and a few superfluous branches may be removed to advantage during the summer months.

Pruning Tools—Two tools are essential for pruning work: a pair of small hand shears and a saw. With these two tools a pruner can do practically all of the work that will be required in bearing trees and most of the work in young trees.

The shears should be made of the best material obtainable, as cheap shears are easily sprung. A good pair of steel shears will withstand heavy work for several years. The shears should be seven to ten inches in length, nine being the size usually preferred.

The saw should be so constructed as to cut rapidly, leave a smooth cut, be as light as is consistent with rigidity and good lasting qualities; and it should have a hand grip that will not tire or cramp the hand or wrist. A saw on which the teeth are set to cut on the "pull" is less tiring to the pruner. Saws with teeth on both edges are objectionable, as they usually are poor in cutting quality and frequently injure bark on the permanent branch.

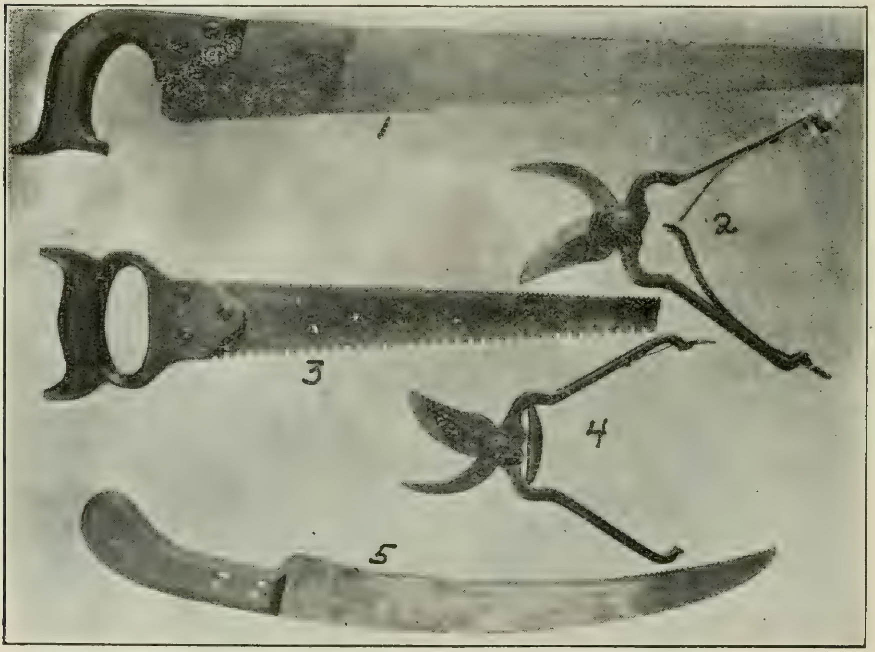


FIGURE 6. Pruning tools. (1) A good type of saw. (3) Saw with two cutting edges. (5) Saw with teeth set to cut "on the pull." A light, inexpensive and rapid cutting tool. (2) An excellent type of hand pruning shears. (4) Hand shears with coil spring. Not as satisfactory as No. 2.

A pair of lopping or wooden handled shears often facilitates the work about young trees and about the lower parts of old trees. It is a somewhat awkward tool to use in the upper parts of bearing trees. Such shears should be about 20 to 26 inches in length and of double leverage.

Pole pruners, six to ten feet in length, enable the pruner to work the tops of trees five to ten years old to better advantage. They should not be used where it is possible to employ the other tools, because work with the pole pruner is, at best, very slow, and the cutting cannot be done as precisely as with other tools.

Wound Dressings—It is considered good practice to paint wounds larger than one and one-half to two inches in diameter with a good white lead to which some kind of antiseptic has been added. An ounce of cyanide of mercury or bichloride of mercury may be dissolved in a little turpentine and thoroughly mixed with a gallon of the paint. A charcoal, brush, grafting wax, such as is used in bridge grafting, makes an excellent covering. See Michigan Experiment Station Circular No. 14, Revised.

TYPES OF TRAINING FOR FRUIT TREES

Fruit trees may be developed according to any one of several different styles of training during the non-bearing, vegetative, or formative period, but we are chiefly concerned with the three more commonly accepted systems.

The Central Leader or Pyramidal Tree system has long been in use, and since it is the easiest to develop, it will receive first consideration. The central branch is allowed to ascend year after year with little or no cutting back, while the lateral scaffold or main branches are kept somewhat shorter by greater or less heading. As a result, the lateral branches are considerably smaller than the central axis, and crotches are formed which seldom split. Strong trees result, but it is very difficult to keep them opened sufficiently to permit light to penetrate to the inner parts, and the tops usually become too high to permit orchard operations to be conducted economically. This system is not favored by many present-day fruit growers.

The Open Center Type of tree usually has three to five scaffold branches well distributed around the trunk and extending outward and upward from it to form the framework. The leader or upright branch is removed, usually the first year. These three to five main branches are cut back to approximately the same height after the first season's growth,

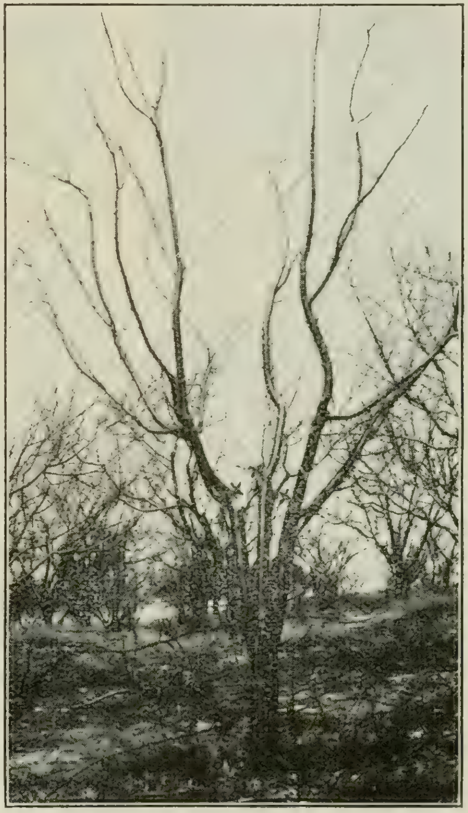


FIGURE 7. Note that the three main scaffold branches were headed at approximately the same height (shown at x) in this open-center type, thus resulting in equal growth and weak crotches. Later, a pocket or cavity will develop which will collect water and dirt and eventually result in heart rot of the trunk.

and this equal heading of all branches is continued until the framework is completed. In other words, each of the scaffold branches is given equal prominence, and any tendency of one to outgrow the others is suppressed. The center is kept sufficiently open to permit the penetration of light throughout the tree. The result is a spreading tree, sufficiently open to permit good coloring of the fruit, and low enough to allow economical handling. This type of tree is easily maintained after it is once started.

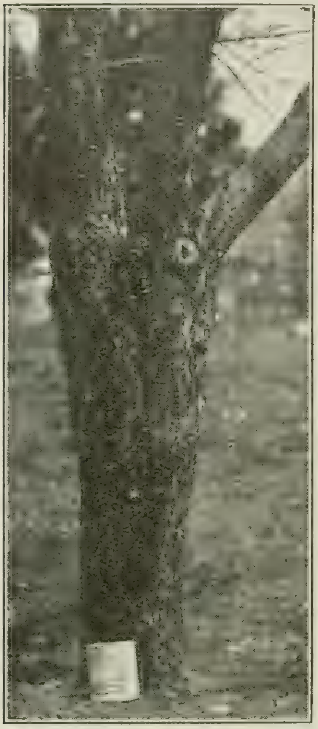


FIGURE 9. A weak crotch and one that offers favorable conditions for the entrance of heart rot organisms.

The open center tree is structurally weak, due to the fact that, in general, the scaffold branches issue from practically the same point, thus forming weak crotches. Frequently one of the scaffold branches splits off and the tree is practically ruined. Many trees trained in accordance with this system, have met this fate. Artificial supports must be resorted to in many orchards with trees trained in such manner. In spite of these defects, however, this system of training is recommended and very generally adopted for some kinds of fruits.

The Modified Leader or Delayed Open Center is the third type of tree. As the terms indicate, it is a modification of the leader tree or is intermediate between the open center and leader types. It combines the more important advantages and eliminates some of the disadvantages of each. The resulting tree is low headed, spreading, and has from six to ten scaffold branches distributed along and about a central axis, thus forming a strong framework with well-formed crotches. It is not possible to secure the several scaffold branches from one season's growth of the main axis and have them properly distributed; so the selection must extend over some three or four years, starting two or three new scaffold branches each year. After the desired number of well-distributed scaffold branches has been obtained, the tree should be opened by discontinuing (removing) the leader.

At this point, attention should be called to the fact that the system of training employed during the first four or five years of the tree's life definitely determines its form, and later attempts to change the form are very frequently accompanied by disastrous results. An established leader should not be removed, after the second or third year, with the idea of developing a strictly open center tree, and, in like manner, attempts should not be made to change an open center tree to a modified leader or leader type. Well trained trees may be developed along any of the above lines and no one system is best for all species, varieties and conditions.

Since many fruit growers are not familiar with the modified leader type of tree, and since it is recommended for most varieties of apples, pears, cherries and European plums, a more detailed description and development of a theoretically ideal tree may be in order.

Assuming that a one-year-old tree has been planted and headed at the desired height, the growth the season after planting will usually consist of an almost upright branch produced from the uppermost bud, and of four or five shorter ones arising from lower buds. If so, two or three of them*, well distributed about the trunk, should be selected in addition to the uppermost one, and the others removed. In cutting or heading back these branches, it should be borne in mind that the longest branch of a group has the advantage and will make correspondingly more growth the following season. Since it is desirable to develop the uppermost branch into a leader for several years, it must be left a little longer than the scaffold branches. The amount of cutting back depends upon the amounts of growth produced. Usually in Michigan it will simply consist in cutting back sufficiently to give the leader some advantage in length. If a good, vigorous growth has been produced the first year, one should leave the lateral scaffold branches 15 to 24 inches long, and the central upright one 20 to 30 per cent longer.

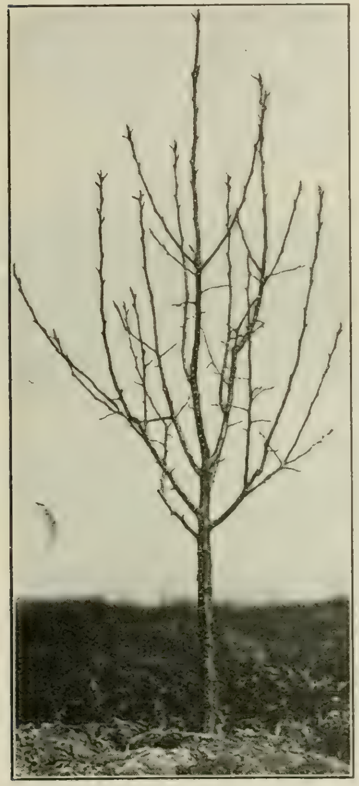


FIGURE 11. A two-year-old Bartlett pear being trained as a modified leader tree. The pruning has been light.

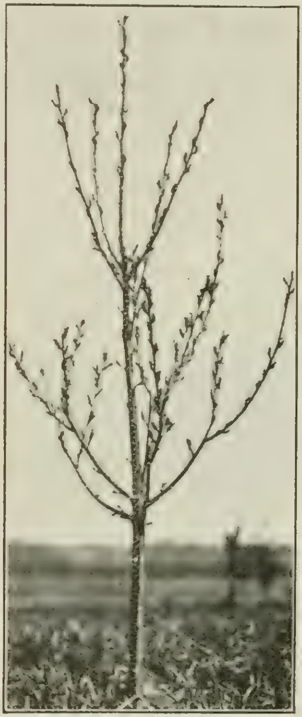


FIGURE 12. A two-year-old sweet cherry showing modified leader system of training. Note that more scaffolds are selected each year than for the apple.

The following winter the leader should be treated in much the same manner as just described for the year previous. The scaffold branches will probably have produced several laterals. Two or three of these should be selected and headed back, if necessary, sufficient to avoid "legginess." Care should be taken, as previously described, to prevent the formation of weak "Y" shaped crotches.

---

*Trees may be expected to attain large size more rapidly if a larger number of branches are left temporarily.

This system should be continued throughout a third and possibly to the fourth year, after which the leader should be suppressed or discontinued. This system of training results in a tree with a central axis or leader about five or six feet in height, with from six to ten scaffold branches extending outward and upward in all directions and spaced along the main axis for three to five feet.

The pruner should develop the several scaffold branches carefully. The heading back should not only be done from the standpoint of the tree as a whole, but also with regard to the relation of the main branches to each other. If certain ones are outgrowing others, the stronger should be headed back more than the weaker ones. If the lower scaffold branches are not developing sufficiently, the upper ones must be cut back more heavily, or the lower ones may be entirely suppressed as real scaffolds and the tree actually becomes high headed. Thus all main branches of the tree must be properly dominant.

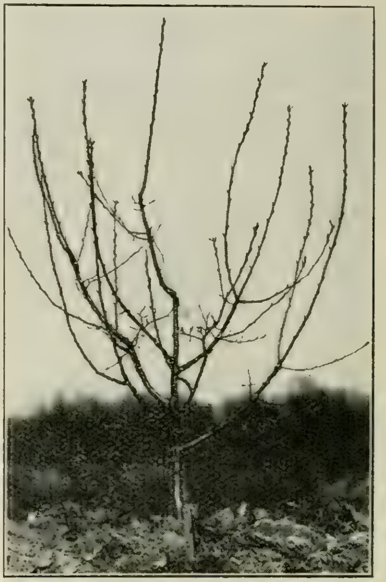


FIGURE 13. A two-year-old Lombard plum showing good distribution of scaffold branches on the lower portion of the tre trunk below the point of heading, but poo on the two-year-old portion of the leade The two lowest branches are perhaps t close to the ground and should have been r moved one year ago.

PRUNING THE YOUNG APPLE

Height of Head—When the lower set of scaffold branches are within two and one-half or three feet of the ground, the tree is said to be low-headed; if they are as much as four feet from the ground, the tree is regarded as high-headed.

The question of height to head is largely a personal one. In general, low-headed trees are more economically pruned, sprayed, thinned and harvested and are less subject to sunscald, while high heading facilitates cultivation underneath the branches. However, the general type and kind of pruning practiced may cause the branches of a high-headed tree to be very low, or may result in the branches of a low-headed tree being sufficiently high for all practical purposes. Again, different varieties have different habits of growth, and this should be borne in mind when determining the height to head. For instance, a McIntosh tree is wide-spreading and the branches quite horizontal, while Duchess or Oldenburg and Yellow Transparent are upright in habit.

Type of Training—The modified leader type is the most favored system of training apple trees among fruit growers who have employed it. However, one will find it impractical to train trees of all varieties, or even all the trees of one variety according to this system.

Severity of Treatment—Immediately after being planted, the tree should be cut back rather severely to reduce the top in proportions similar to root reduction at the time of digging in the nursery, in order to get the desired height of heading, and, in the case of two-year-old trees, to reduce to two or three scaffold branches. If a one-year-old tree is planted, the pruning will usually consist in cutting the whip back to the desired height of heading. After such a tree has been planted for a year, the pruning will remove all but the selected scaffold branches, and these may be slightly headed back to give the central leader sufficient advantage and to regulate the balance and symmetry of the young tree.

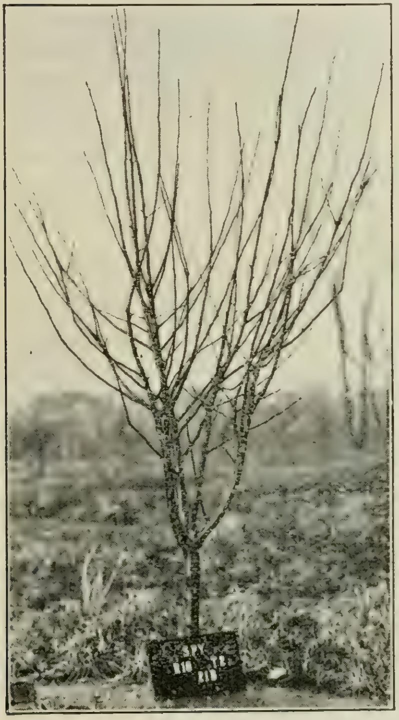


FIGURE 14. This tree is the same variety and age as the one shown in Figure 15, but it has received no pruning except that given immediately after planting.

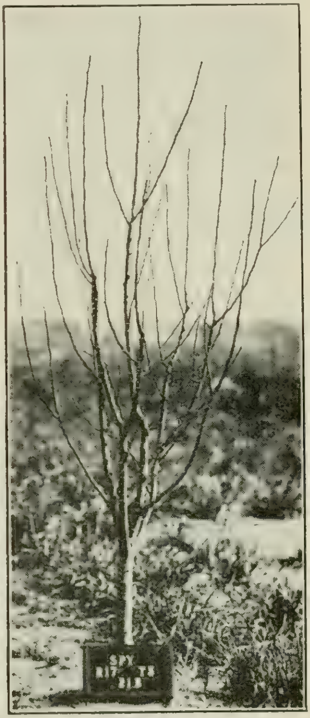


FIGURE 15. A three-year-old Northern Spy which has had a moderately heavy pruning annually. This has consisted mostly of thinning out shoots of the past season's growth. A small amount of heading back to improve form has been given.

Fruit growers disagree considerably as to the treatment that should follow that outlined in the above paragraph. Some hold that 50 to 75 per cent of the growth should be removed in thinning, and then 50 to 75 per cent of the remaining 25 to 50 per cent removed by cutting back, and that slightly less percentages be removed each year until the tree comes into bearing. This is a very severe pruning, and, while it may result in a very well formed tree, fruit production is unnecessarily delayed.

On the other hand, some fruit growers would not touch apple trees with pruning tools after the pruning following the first year's growth in the orchard until they have established the bearing habit. Such a treatment leads to early bearing, but strength of framework is sacrificed in many cases. Then there are other growers who take various stands intermediate between these two extremes. The writer believes that the fruit grower can afford to sacrifice neither early fruit production nor strength of framework.

Apple trees which are expected to be comparatively short-lived, such as those planted as fillers (trees which are to remain in the orchard for some 15 to 25 years and then be removed to make room for the permanent trees) are best grown from the time the trees are one-year-old (from date of planting in the orchard) until after they are bearing well without any pruning except the occasional removal or cutting back of decidedly ill-placed or very wayward branches. Such a treatment will encourage much earlier fruit production. The trees will undoubtedly be poorly shaped and crowded, and some may be ruined by breakage after they reach bearing age. Heavier pruning may be practiced after these trees come into bearing, thus partially correcting some of the faulty growths.

The above practice is not a wise course to follow in training young trees that are expected to stand in the orchard for 60, 80 or more years. Such trees should have very high valuations when thirty or more years old, and any breaking down of trees at such times, because of faulty training in early life, will mean heavy financial loss. Thus the training of a young apple tree might be compared to the building of a foundation for a building. If the building is small and of a temporary nature, less importance is attached to the construction of the foundation than if it is to be a large building that is expected to serve for a half century or more.

Thus it would appear that moderate or light pruning should be given apple trees until after a substantial framework has been developed, when the pruning should become very light in character. In kind, this pruning should be for the most part a thinning out, under Michigan conditions. In other words, all of the longer growths should be removed following the first two or possibly three seasons' growth, except those branches selected to form the framework. Cutting back during these two or three years should usually be very light and should be done more with the idea of establishing a proper balance between the parts of the tree.

Spurs and other short growths in the middle of the tree and along the main branches should not be cut out, as such wood fruits early and tends to maintain an even distribution of fruiting wood throughout the tree—the ideal fruit condition.

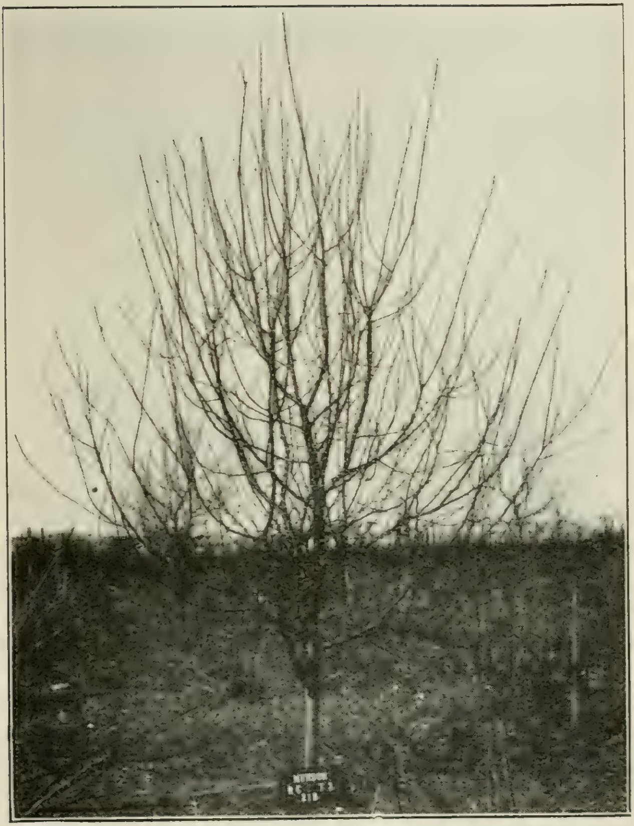


FIGURE 16. A six-year-old Jonathan tree which has received moderate pruning until one year before this picture was taken when the treatment consisted of very light thinning. The tree was lightly thinned after this picture was taken and it produced a fair crop of fruit the following season.

PRUNING THE APPLE TREE JUST COMING INTO BEARING

Fruit trees should be handled particularly carefully when they reach the age or size at which fruit production should begin. In many ways this is their most critical period. During the first few years following planting, they usually make a vigorous growth. Their twigs are relatively rich in nitrogen and low in starch and other carbohydrates. Severe pruning during the period just preceding fruiting tends to continue this low carbohydrate content and thus delays fruiting, for fruit bud formation is associated with the accumulation of carbohydrates. Intensive cultivation and fertilization have similar effects. If pruning is largely confined to a very light thinning out, and this is in conjunction with moderate cultural practices, there is a tendency for the carbohydrates to accumulate, and the tree becomes fruitful.

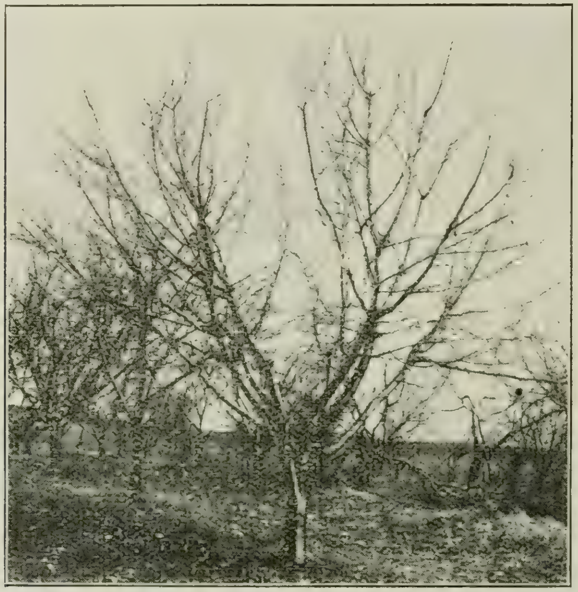


FIGURE 17. This tree is in need of thinning that should consist in the removal of many small branches, seldom over two years old, rather than the wholesale slaughtering such as its neighboring trees had received and is illustrated in Figures 18 and 19.

It is evident then, that, after the framework of the young apple tree is established, the pruning should be limited to the removal of injured and diseased branches, the occasional removal or shortening of closely parallel and crossing limbs, and the thinning out of a limited amount of superfluous new growth to admit light to all parts of the tree. Even this treatment should be very largely confined to the previous season's growth. The grower may be warranted in omitting the pruning for a year or more in cases where the trees

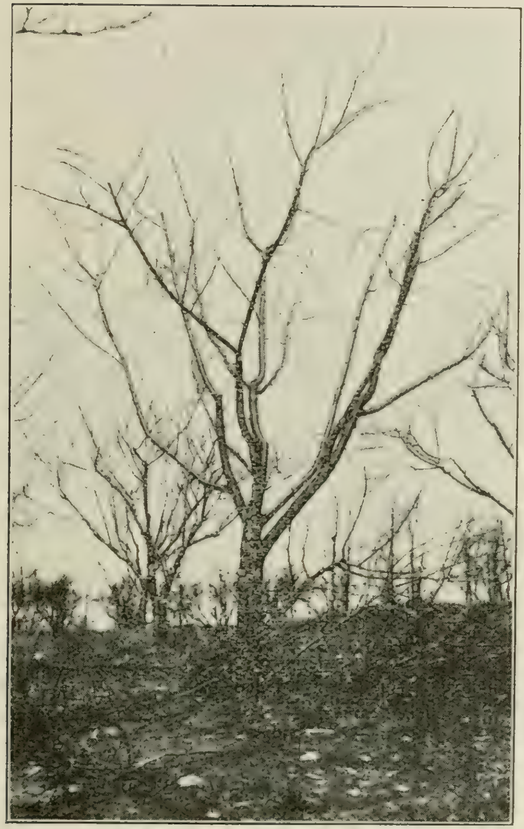


FIGURE 18. The large forked branch lying on the ground and leaning against the trunk was removed from the center of this tree to "open it up." Note the amount of brush underneath this tree. It was ready to begin fruit production, but three years of expert treatment will be required to bring it into commercial fruiting.

show little tendency toward fruit production. Pruning of any kind at this particular stage is more likely to delay than to encourage production, and it should not be regarded as a means of bringing the tree into bearing. To bring the vegetative tree into bearing, it is frequently necessary to alter cultural practices. Nitrogenous fertilizers should seldom be applied, and it may be necessary to discontinue the growing of crops requiring inter-tillage and to sow the orchard to clover or alfalfa, or, in case of very vegetative trees, to grass.

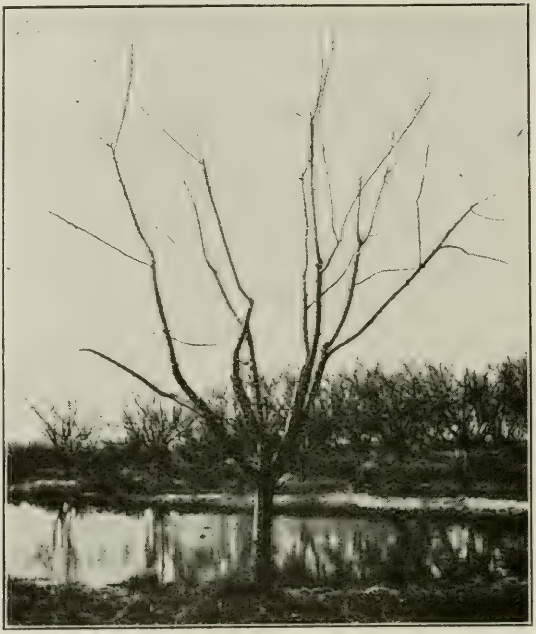


FIGURE 19. An orchard pruned after this fashion is worth $100 to $200 per acre less than before pruning. Before pruning the trees were similar to the one shown in Figure 17.

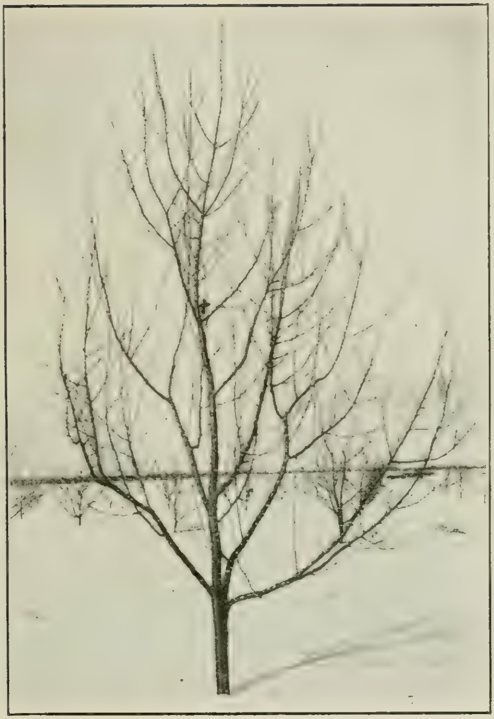


FIGURE 20. This eight-year-old tree should receive a very light thinning of the previous season's growth, rather than the severe pruning the trees in the background have experienced. This tree shows a fair distribution of scaffold branches. The leader should have been removed at X about four years ago to have formed a modified leader type of tree.

PRUNING BEARING APPLE TREES

After the bearing habit seems well established, or in other words, after the tree has been producing moderate crops for two or three years, the pruning may become more severe. In other words, the trees may have been very lightly pruned for several years, and probably there will have accumulated a considerable quantity of superfluous wood, and the trees will undoubtedly have become too dense for optimum fruit production, especially in the interior portions. In general, such pruning will consist in thinning out sufficiently to permit light to penetrate to all parts. This thinning out should be largely confined to the removal of many small branches about the outer parts of the tree rather than the cutting away of fewer large branches. In addition to this major treatment, it may consist of heading any unruly or wayward branches back within bounds, preventing the formation of weak crotches, heading back branches tending to grow into others, and keeping the fruiting machinery (spurs) well distributed and functioning throughout the tree.

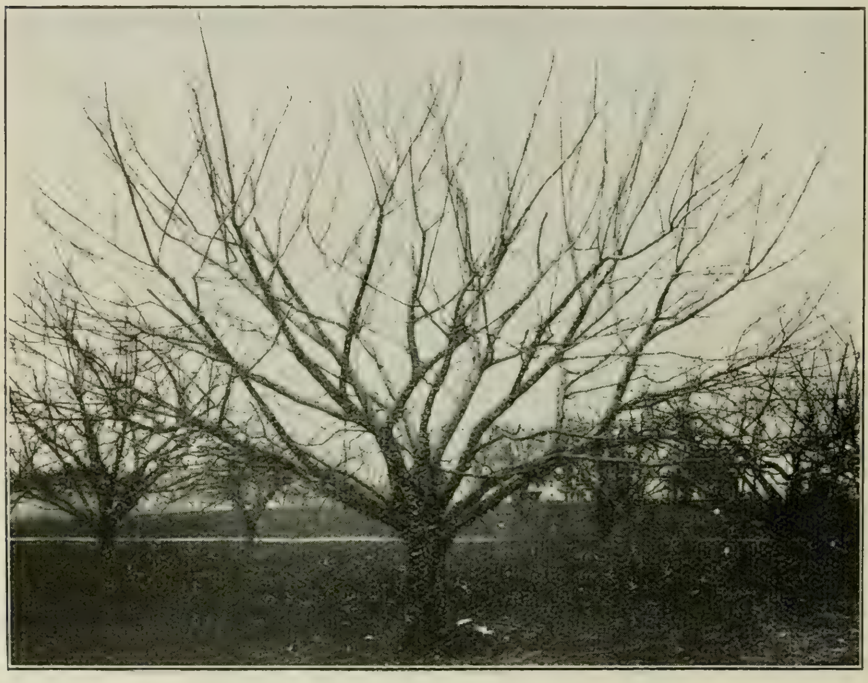


FIGURE 21. This Northern Spy tree is in need of thinning out about the outer parts and top. There is little necessity for making cuts larger than three-fourths of an inch in diameter, but many of these small cuts should be made. The lower central part of this tree is too barren of fruiting wood.

Thinning Bearing Trees—The average more or less neglected bearing tree is so thick about the outer parts that an even distribution of functioning fruit spurs cannot be maintained. Thus the outer ends of the branches should be considerably thinned to permit a free circulation of air, ample light to promote the development of fruit spurs and fruit, and more thorough spraying. The common mistake is to pursue the easiest course and remove a few rather large branches, but such a practice leaves holes and does not result in an even thinning or an even growth. Again, too much large wood is removed, resulting in a heavy vegetative growth near the base of the removed branches. In thinning out the outer parts of the trees, less vegetative disturbance will result if many small branches—seldom over an inch in diameter—are removed in such a way as to leave the outer fruiting wood evenly distributed and still open enough to permit the entrance of light and the circulation of air. This type of work is best performed when the pruner climbs out near the ends of the main branches where he is able to work with a saw and pair of hand shears. This requires time, but experience has proved that the extra labor is repaid many times through better results. In case old trees are bearing too many clustered, weak or inactive spurs, it is advisable to thin them to admit light, prevent overbearing of small fruit, and to stimulate the remaining spurs.

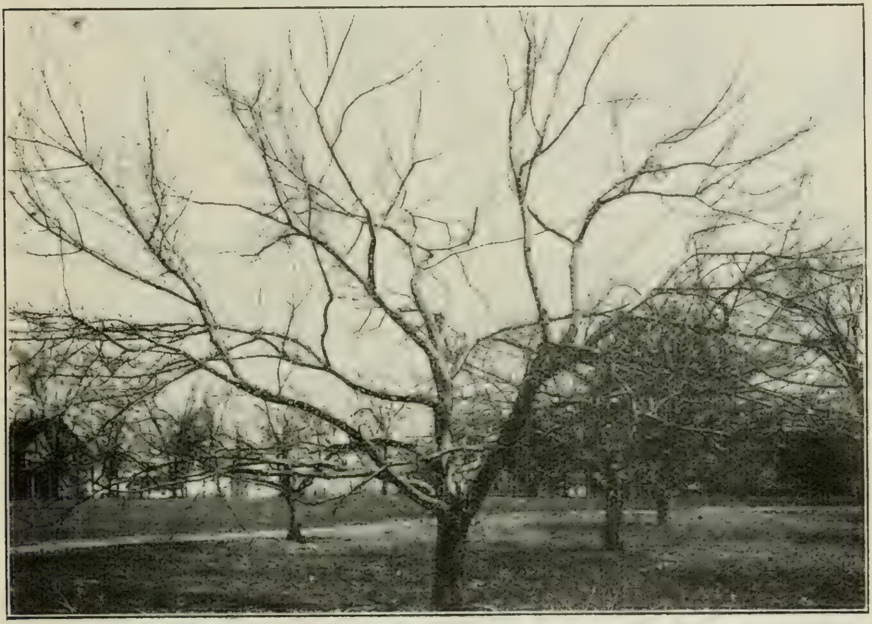


FIGURE 22. The pruning in this tree has been rather severe. Bearing capacity has been limited too greatly and some parts of the scaffold limbs are so much exposed that sunscald may result.

Lowering Tops of Trees—Fruit growers fully appreciate the inconvenience of too high tops. Many are bringing them down so that they may be successfully, as well as more economically, handled. There has been a certain tendency, however, to determine the height to which the trees should be reduced and then remove large branches to accomplish this. The result is that some parts of the tree which have been partially shaded are unduly exposed to the sun, and scald results. In some orchards the bark on the larger branches has been killed fully one-third the way around the branch. Again, water sprouts usually develop in profusion following such heavy cutting back.

It is usually possible to reduce the height of these tops by cutting back some of the upright branches, some three or four to seven or eight years in growth, to a side branch. Again, the remaining side branches may be shortened somewhat. Such measures usually bring the tops of the trees five to ten feet nearer the ground, and are not especially detrimental to the tree as a whole. This cutting, however, often induces wood growth, which should be removed in later years. If an old tree has produced little growth in the top, but the top is too high, two or three years should be taken to lower it.

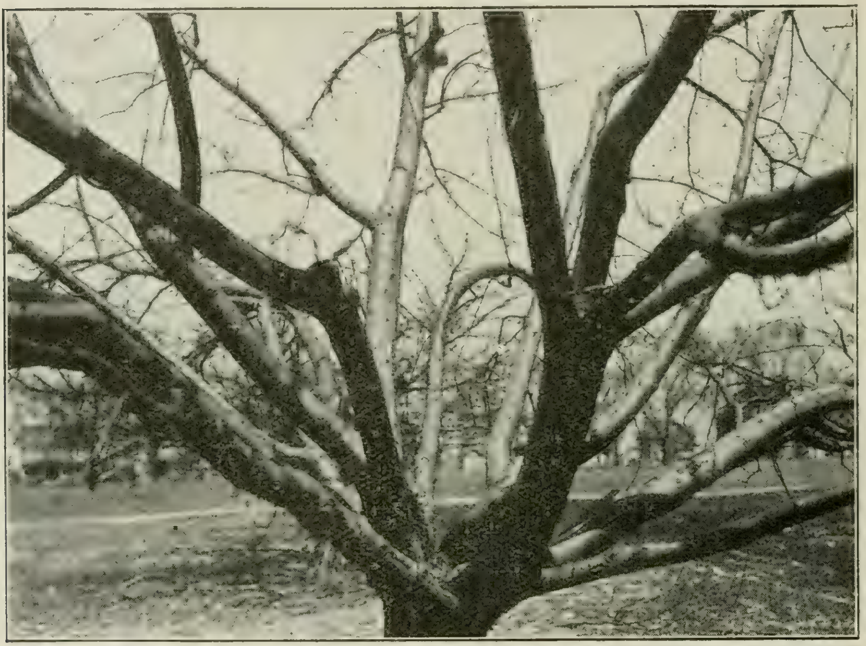


FIGURE 23. Near view of some scaffold branches showing the total absence of fruiting wood within a radius of ten feet of the head of the tree. This portion of the tree should be utilized for fruit production.

Distribution and Re-establishment of Fruiting Wood—A scaffold branch should have several good lateral branches well spaced along its entire length, each lateral supporting its share of fruiting wood. Such a tree can support a given load to better advantage and carry a much larger crop of fruit. When pruning the young tree always leave fruiting wood, if it is located where it will have a chance to develop. The tree will fruit earlier and heavier. Bearing orchards are frequently seen in which trees have been stripped of all fruiting wood except near the ends of the branches. In other words, all the fruit is borne out on the ends of the branches instead of being distributed throughout the tree. In many trees there is no fruiting wood within a radius of fifteen or even more feet from the trunk of the tree. Fruiting wood may be developed in the course of three or four years in a tree in which the scaffold limbs are bare, by the use of well situated water sprouts. They should be cut back leaving them from six to twelve inches in length to encourage the development of side branches. These in turn should be slightly headed back the following year. After this, the heading back should be materially lessened to encourage the formation of fruit spurs. To make this operation successful it is essential that the trees be thinned about the outside to admit light sufficient to allow the development of fruit spurs and to color the fruit.

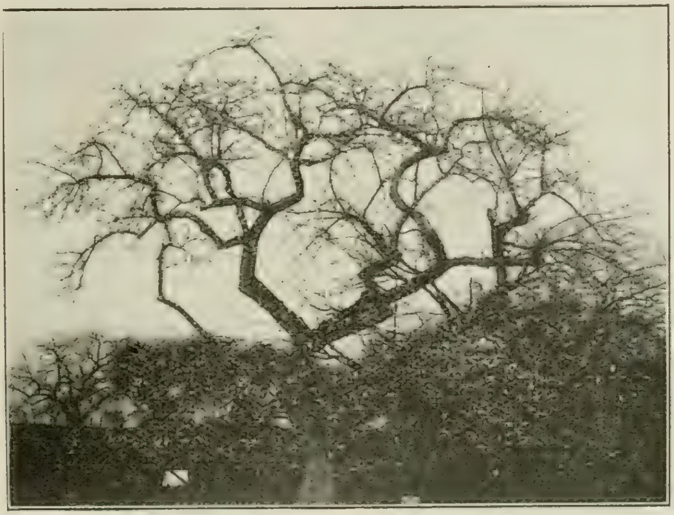


FIGURE 24. An old apple tree which has just been pruned. All water sprouts and other growths were removed from the lower portions of the tree, but no thinning was done in the top, The top should have been well thinned and some of the growths on the lower portions saved to re-establish fruit production in those parts.

The average man has a tendency to cut out one or both of two branches which cross, because they have been instructed to remove cross branches. In many cases better results would be accomplished if the branch were simply shortened to a lateral. Suppose, for example, that a side branch had been left to fill in a space in a tree, and that this branch continues growth, growing across another branch some three feet from the first branch. This long cross branch should often be cut back so as not to interfere with the branch it is crossing, but still fill the space that it was intended to occupy.

PRUNING THE PEACH

After planting, the peach tree should be headed at a height of from twelve to twenty inches—fifteen is a good average. Some growers prefer to have the head just above the surface of the ground, but where trees are headed lower than twelve inches considerable difficulty is experienced in removing borers. Heading at 20 to 26 inches, as practiced by some growers, has no material advantages and increases the cost of pruning and harvesting. If the tree has a few side branches when it comes from the nursery, they should not greatly influence the height of heading. If they occur above the point of the desired head, the straight, branchless tree or whip will develop side branches that may be utilized as scaffolds. If side branches have developed from points below the height of head, four or five of them may be saved and headed back to from two to five inches each.

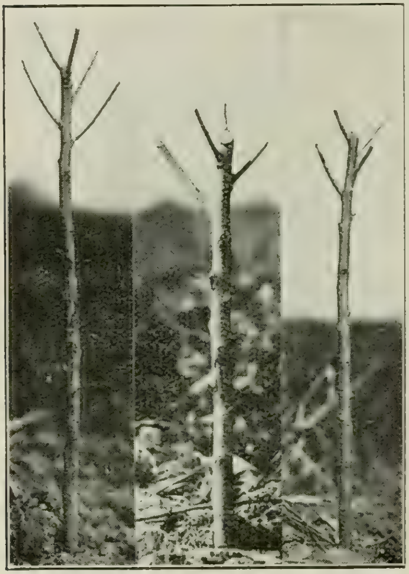


Figure 25. The secondary branches of one-year-old nursery peach trees may be cut back to stubs as shown; or they may be entirely removed, thus reducing the newly planted tree to a straight whip.

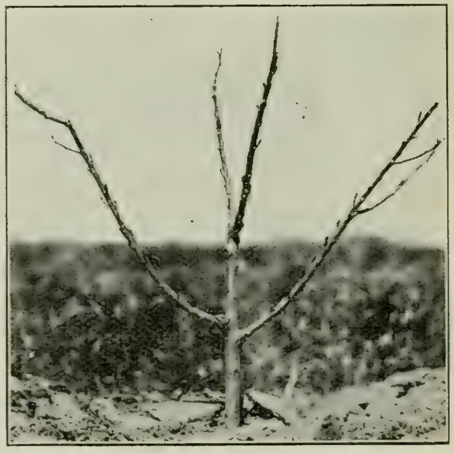


Figure 26. A one-year-old peach tree after pruning. Note that the four scaffold branches are cut back to about the same height.

Form of Tree—The open head type of tree has been almost universally accepted as the best for commercial purposes. This results in a low, wide-spreading tree in which practically all the work may be done by men standing on the ground or on low stepladders, makes possible the production of a good supply of vigorous fruiting wood throughout the center and along the main branches, and admits sunlight and permits a circulation of air, thus insuring well colored fruit.

First Year—After the tree has made a season's growth, from three to five scaffolds, or main branches, should be chosen with a distance of two or more

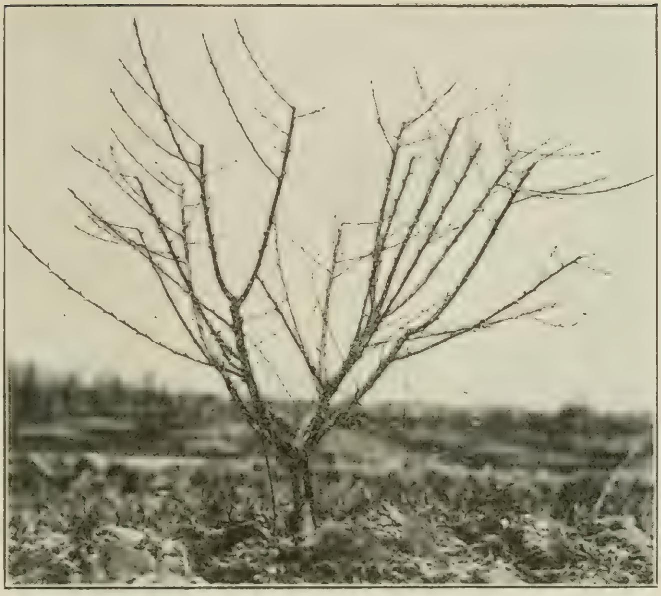


FIGURE 27. A two-year-old peach after pruning which consisted of heavy thinning out and cutting back to secondary laterals.

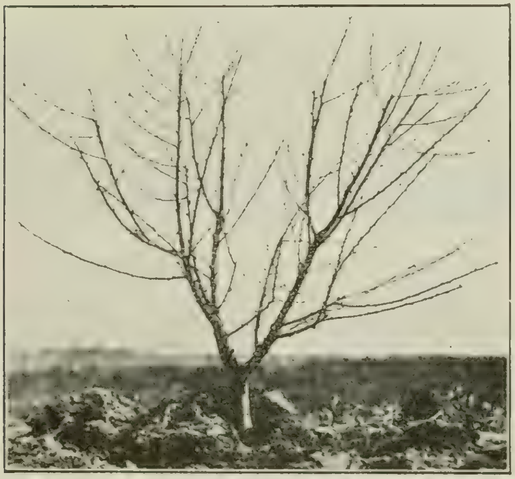


FIGURE 28. A two-year-old peach tree that has not been thinned sufficiently, making it necessary to cut into two-year-old wood the following year.

inches between their points of origin and so as to form a well-balanced tree. A common point of origin, however, is not seriously objectionable in peaches. Four main branches are preferable, but often the individual tree will be of a better shape if three or five are left, although the latter number may result in more or less crowding. Growths other than the selected scaffold branches should be removed.

The scaffold limbs should then be cut back rather heavily to produce strong, stocky branches that can better carry the loads of fruit in later years. If the growth has been rather short and stocky, less cutting will be necessary; but long, slender branches should be cut back more severely. With an ordinary amount of growth, of 30 to 36 inches, branches of from 18 to 24 inches in length should be left. In case the branches have made an unequal amount of growth, the weaker ones should be left slightly longer than the stockier ones so as to give them the advantage the following season, thus resulting in a balanced tree. Generally the branches should all be cut back to the same height. It will usually be possible to cut back to lateral branches. In such cases, two or three of these laterals may be left on each scaffold and tipped back. If the lateral branches have all developed from beyond the place where the scaffold should be cut back, the laterals should be ignored and the selected scaffolds cut back to outside buds.

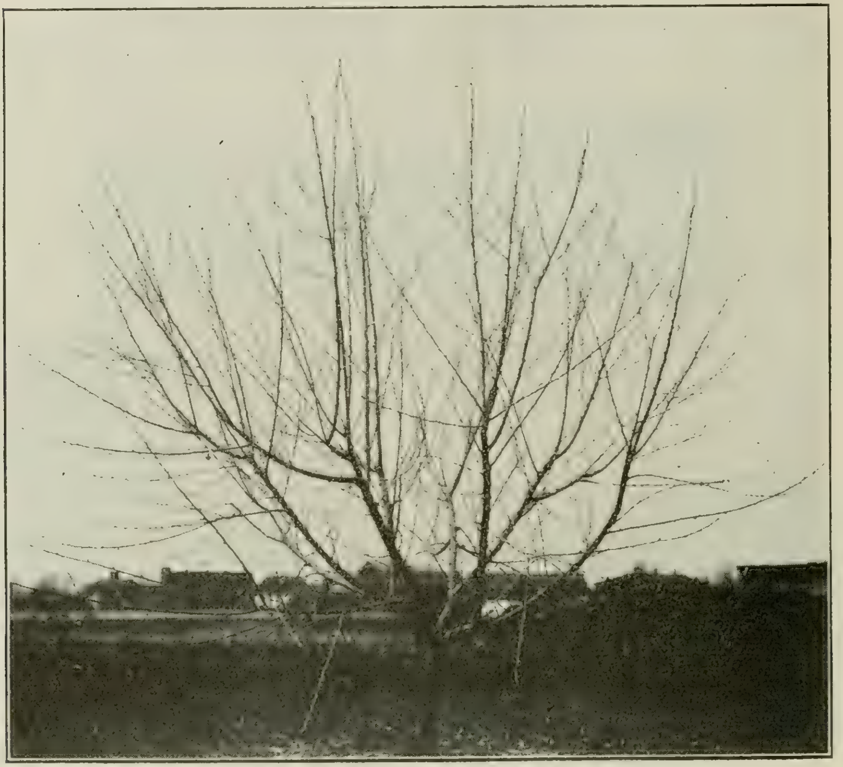


FIGURE 29. A vigorous growing three-year-old peach tree before pruning.

Second Year—During the second growing season, several lateral branches will probably develop from each of the main branches. The following winter, two or three well spaced laterals, extending outward from each main branch, should be selected and all the other growth removed, except a few small twigs in the center of the tree, which may be headed back for early fruit production. These laterals should be headed back, but usually not so severely as the year previous. Since the idea is to obtain a low, spreading tree, this second year's growth should be left from 18 to 30 inches long, depending on the amount of growth produced and its direction.

To produce a well-shaped open-center tree, one should leave approximately the same amount of wood on each of the main branches, so that the top of the tree is almost level after pruning; or, in other words, the ends of the top branches should all be about the same distance from the ground. Of course the weaker growing scaffolds should be given some advantage by leaving them slightly longer.

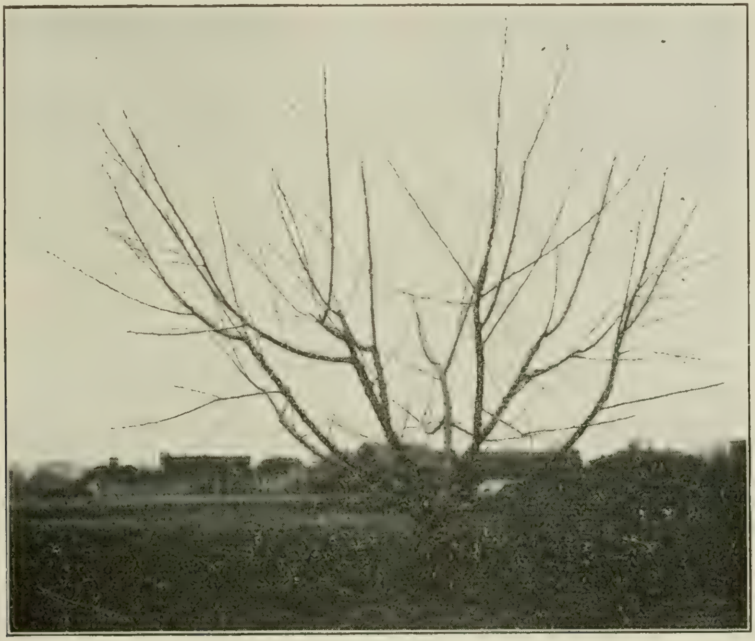


FIGURE 30. Tree shown in Figure 29 after pruning. Note relative amounts of thinning out and cutting back.

A stronger framework will be formed if one branch of each scaffold is recognized as a leader and left a few inches longer than the others. In fact, the scaffold leader should be much more in evidence in the peach than for other fruits. Thus if three branches of the second season's growth are selected, usually the middle one should be left a few inches longer than the other two.

Third Year—During the winter following the third year's growth, two or three outward growing laterals should be selected from each branch headed back the year previous. These branches, selected to continue the framework of the tree, should be headed back, removing perhaps a third to a half of their growth. Again, one should try to leave the tree as a whole well balanced, but he should destroy the balance of individual limbs by unequal cutting, or by leaving a leader.

There will probably be a great number of twigs or branches throughout the lower parts and center of the tree. Those that are placed to receive light and have plenty of room for development should be tipped back 25 to 50 per cent, depending on the character of the growth, and saved for fruiting wood. Undoubtedly a large number of small twigs will have to be removed to admit light and avoid crowding. Although fruiting wood is desirable along the main branches and extending to the center of the tree, the pruner should attempt to keep this growth rather short and thus maintain the open center.

PRUNING THE BEARING PEACH TREE*

If the tree has been built along the lines previously outlined, it will be low and spreading, making it possible for the several orchard operations to be done by men or women standing on the ground. Future pruning should be such as will retain and encourage the formation of fruiting wood throughout the center as well as the outer parts of the tree, remembering that the peach bears its fruit on wood of the previous season's growth, and that a goodly supply of new wood should be produced each season. Failure to prune the peach tree for even one season will result in a thick top with a small amount of fruiting wood far removed from the main framework, and probably in a weakened tree producing many small and inferior fruits.

If the tree is making a very vigorous growth, each of the main branches produced during the previous season should usually be cut back to a good lateral or secondary branch produced during the same season. Two or three of these secondary lateral branches may be selected and tipped back so as to leave most of the fruit buds, or they may be left without tipping, provided the growth was not strong. If the previous season's growth did not exceed 18 to 24 inches, the selected branches should usually be headed back 25 to 40 per cent, or so as to leave a satisfactory number of fruit buds on each branch. The grower should strive to keep the tree low, and to accomplish this it is frequently advisable to cut back the larger branches into two- or three-year-old wood, and to a good, wide-spreading lateral branch of the previous season.

The outer parts of the tree should be thinned out to avoid crowding and to permit a free circulation of air and access of sunlight. A good supply of bearing wood should be retained throughout the centers and lower parts of the tree. This wood should be headed back and should never be allowed to develop enough to fill the center of the tree. Old twigs that have ceased to produce a goodly number of fruit buds should be removed to make room for the development of new wood.

Pruning Neglected Peach Trees—Peach trees which have not been properly pruned for two or three seasons usually attain the shape of a "naturally grown" tree; that is, the middles become brushy and frequently higher than the other parts of the tree, and the annual growth is short. These trees gradually become weaker and produce only a small amount of undersized fruit. It is usually advisable to open such trees by removing the branches from the center and then cutting back the remaining branches into old old and to outward growing side branches. The dead and weak wood should then be removed. The smallest twigs in the middle of the tree can sometimes be knocked off with the pruning tools without serious injury and with much saving of time. The trees should then be thinned out, leaving only the most vigorous, well distributed wood. A good growth, well lined with fruit buds, will usually result the following season. During the following winter this new growth should be thinned out and headed back, leaving a good supply of fruit buds.

---

*See 32-year-old peach tree on front cover of this circular.

Renewal of Fruiting Wood—In many old peach trees the fruiting wood is scarce and far removed from the ground, and the trees seem to lack vigor. If the fruit buds in such trees have been injured to such an extent that little or no fruit will be produced during the coming season, these trees may be lowered, renewed, and thus shaped to produce better crops in future years. The amount of cutting back will depend entirely on the shape and condition of the individual tree. "Dehorning," as generally defined, is advisable only under special conditions. If the trees have become quite upright, it will usually be advisable to head the main branches back to lateral, almost horizontal, branches; probably removing some three to five years' growth. If they have not attained a great height, but are lacking in vigor and the fruiting wood is scarce, some two to four years' growth of the main branches should probably be removed. This, in conjunction with proper fertilization and cultivation, should result in the formation of a large amount of vigorous growth which may be thinned out and headed back the following winter. If the heading back is very heavy, such as might be termed "dehorning," there is danger of a long, thick growth being produced and the lower parts being so shaded as to prevent the formation of many fruit buds where they are most desired. Again, such drastic treatment usually results in two years without fruit.

Pruning Winter-Injured Fruit Trees—During occasional severe winters the peach wood becomes injured, as indicated by the brownish color of the sapwood. Although "dehorning" or severely cutting back such injured bearing trees has been quite generally practiced, investigations and observations following the injury during the winter of 1917-18 are conclusive enough to warrant the grower employing less severe practices. Trees in which the longer branches were cut back into three- and four-year-old wood and less prominent branches more lightly headed seemed to give the best response. In fact, it would appear that no pruning would give better results than "dehorning." Again, better results will evidently be obtained if the heading back is delayed until after the sap has been active for a few weeks.

As previously mentioned, if the fruiting wood becomes scarce and far removed from the trunk, peach trees should be lowered. Advantage should be taken of a season when it appears that a light crop will be produced to do this work. For this reason it is sometimes recommended that pruning be delayed until the prospects for a crop can be determined or until after blossoming. Experience has shown that if pruning is thus delayed, some of the trees will not be pruned. It therefore seems best to preceed with the regular pruning in the winter or early spring; then, if frost ruins the prospects of a crop, it is not much trouble to go over the trees a second time and cut them back into wood three or four years old.

PRUNING THE PEAR

The pear should generally be trained and pruned in a manner similar to that recommended for the apple. Some growers prefer the open-center type of training, maintaining that a lower tree will result, and that blight may be more easily controlled. The pear, however, lends itself more readily to the leader rather than open or vase-shaped system of training. There are advantages in both systems, but since the modified leader tree may be opened up after suppressing the leader, it is usually given preference.

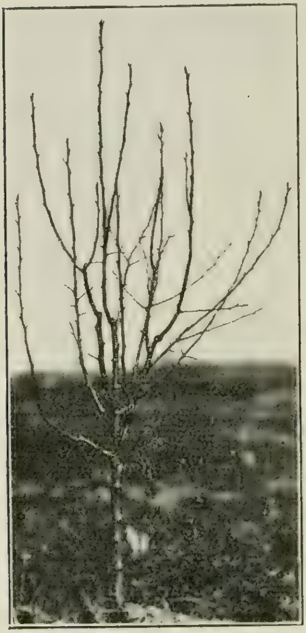


FIGURE 31. A two-year-old Bartlett pear. Photograph taken after pruning which was almost entirely a thinning-out.

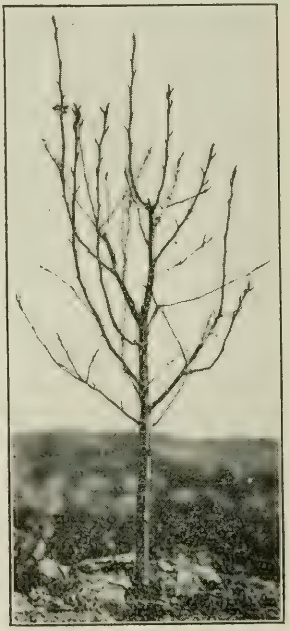


FIGURE 32. This two-year-old Seckel pear has just received a light thinning-out and very light tipping-back. The tallest branch should have been headed back to the X to prevent it from assuming the "lead" and thereby developing into an unsymmetrical tree.

Since the pear has a strong tendency to assume an upright habit, the grower should cut back to outside buds or to outside lateral branches. In case of varieties having a decided upright tendency, it may be advisable to cut to a bud just above an outside bud with the idea of cutting back into two-year-old wood to the outside lateral the following year. The grower should be particularly careful to destroy balance in individual limbs, but not in the tree as a whole, by cutting back branches, because of the upright habit of growth and tendency to form weak sharp-angled crotches. It is a good practice to remove spurs which may develop from time to time on the trunk or on the

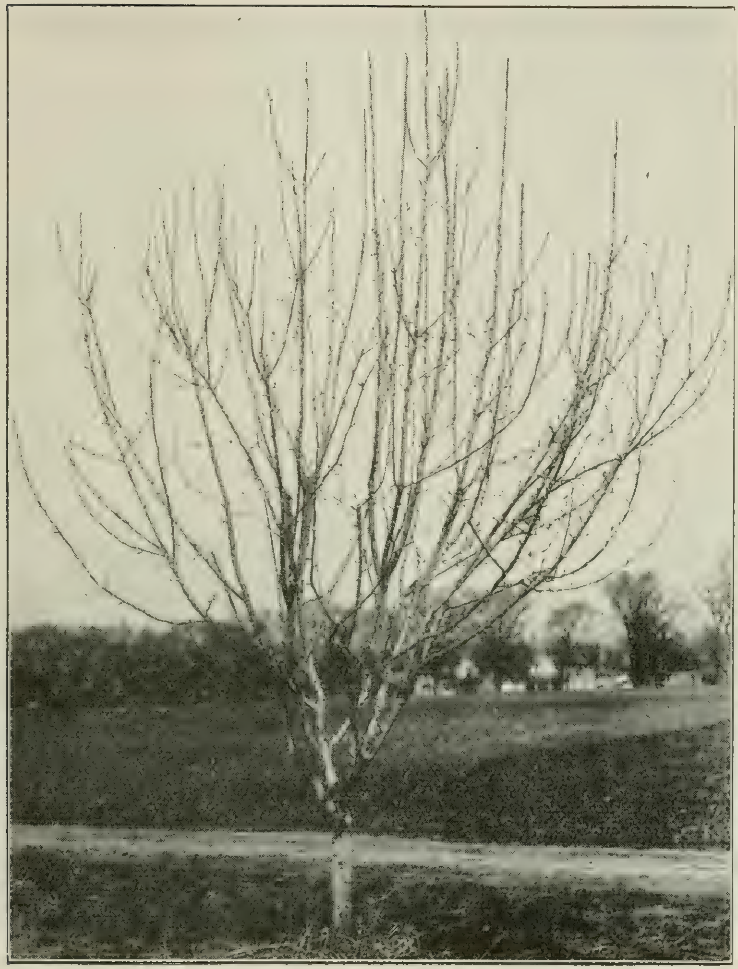


FIGURE 33. This five-year-old Kieffer pear has received a light thinning out of one- and two-year-old wood, as shown by the prunings on the ground. Note the quantity of fruit spurs. It produced its first heavy crop the succeeding summer.

lower parts of the main scaffold branches to prevent blight from gaining an entrance to the main framework.

Because of the tendency for a pear tree, especially a young one, to send out several shoots following the cutting back of a branch, thus resulting in a very compact top requiring heavy thinning, it is advisable to confine the pruning of three-year-old to seven- or eight-year-old trees very largely to a thinning-out process. Such cutting back as is practiced should be light. After the bearing habit seems well established, however, some cutting back in the tops of the trees to keep them from becoming too high may be advisable.

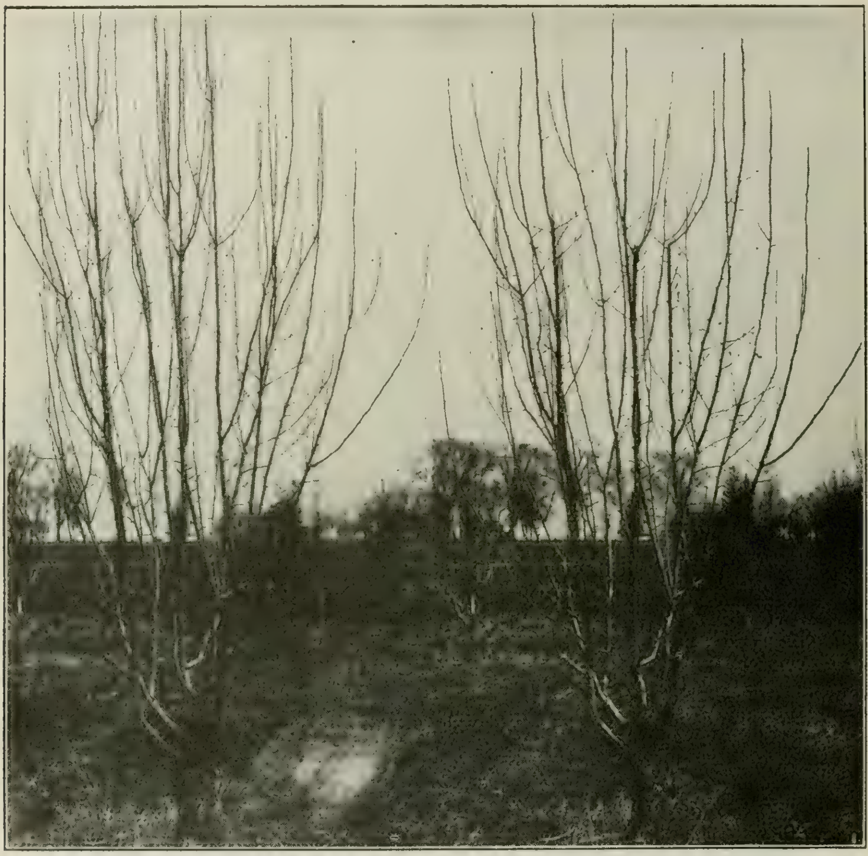


FIGURE 34. A five-year-old Kieffer pear before and after pruning. Note that the practice was mostly thinning-out with a small amount of heading back to laterals at the base of two-year-old wood. This tree was poorly headed.

PRUNING THE CHERRIES

Since the growth and fruiting habits of the sweet and the sour cherry differ, they require different pruning treatments, and it seems better to discuss them separately.

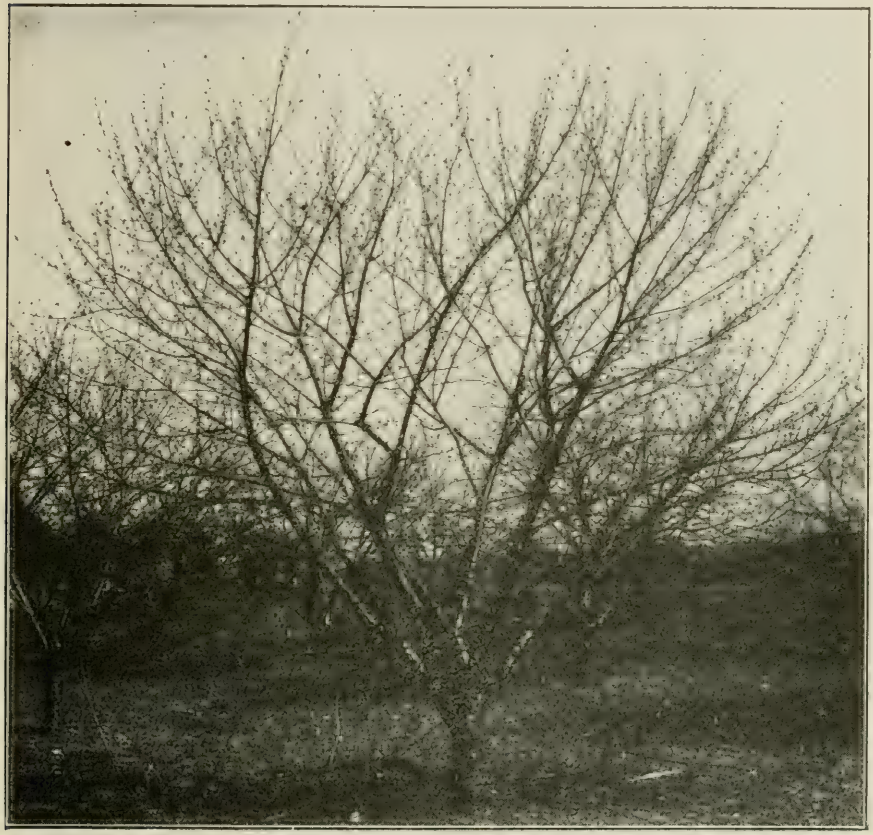


FIGURE 35. This Montmorency cherry tree had not been pruned for three or four years previous to the treatment it has just received. The pruning consisted of the removal of many dead and weakened twigs throughout the lower part of the tree and a thinning out of the top and outer parts. The prunings under the tree show that many branches less than one-fourth inch in diameter and few larger than that were removed.

Sweet Cherry—The young sweet cherry tree may be trained in much the same manner as the apple, except that growth habits make it advisable to do less cutting back and more thinning (See figure 12). Perhaps a brief statement regarding growth characteristics will explain the necessity for these slight differences in treatment.

The fruit is borne principally on laterals or spurs whose terminal bud is a leaf bud. Growth of the spur is continued each year from its terminal leaf bud. The lateral buds formed on one-year-old shoots of young trees usually produce new shoots or remain dormant, resulting in the development of a comparatively large number of shoots. Thus the young trees are usually thick, compact, and strongly vegetative. This type of growth may be produced from the lateral buds for several years, and bearing is correspondingly delayed unless the trees are carefully handled. As the trees reach bearing age, however, some of the lateral buds develop into fruiting spurs and fewer of them develop into shoots. Frequently this proceeds to the extent that in old bearing trees practically all of the lateral buds develop into fruit spurs or remain dormant, and few, if any, develop into shoots. Thus, only the terminal bud of a last-year's branch produces vegetative growth, and the result may be a

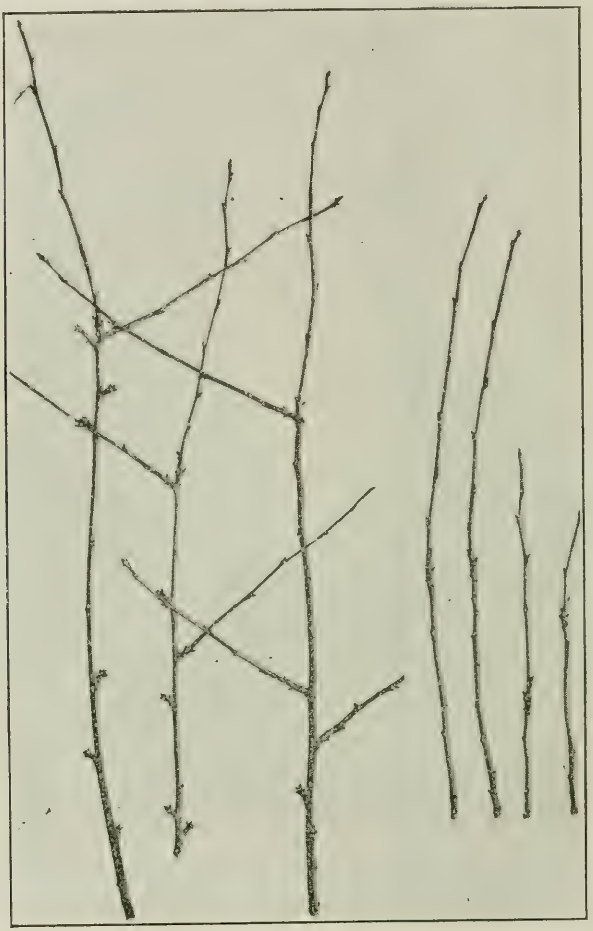


FIGURE 36. When sour cherries produce sufficient growth to permit the development of lateral fruit buds, lateral branches and spurs, a desirable fruiting condition like that shown on the left is obtained. When the growth is short as shown on the right, the lateral buds are practically all blossom buds and there is little opportunity for twig and spur development.

few long, straight branches, rather than a more compact head. The problem, then, is to induce more rebranching and more growth. Heading back to the base of one-year-old wood, or sometimes in two- or three-year-old wood, is advisable. This treatment should be supplemented with such cultural practices and fertilizer treatment as will better growth conditions.

Thus, the treatment for sweet cherries is light compared to that for apples and peaches, and it differs in kind in that more thinning-out is necessary for young trees and more heading back for old trees.

Sour Cherries—The modified leader type of tree seems to be preferred by commercial sour cherry growers. Generally speaking, the young sour cherry may be trained as the apple, except that more scaffold branches, four or five, should be left each year and the leader suppressed after two or possibly three seasons of growth. A greater number of scaffold branches are desirable for sour cherries than for other fruits, because of the branching habits. The young sour cherry will require little or no tipping back, as it has a habit of freely producing lateral branches without heading back. Even the thinning is very light during this period, it being confined mostly to a removal of the larger branches, other than main or scaffold ones, during the first two years.

After the general framework of the tree is established, the pruning is mainly limited to a removal of weak and dead twigs; thinning out sufficiently to keep up a good supply of functioning wood throughout the tree, and heading back occasional branches in the top to prevent the trees from becoming too high.

Normally, the sour cherry bears its fruit laterally on long growths and on short growths or spurs similar to those of the sweet cherry. Thus its fruiting habit is intermediate between that of the peach and sweet cherry. However, there is a great tendency, in Michigan, for cherry trees to produce fruit almost entirely from the lateral buds of the longer growths. In other words, few spurs develop to maintain fruiting in the two-year-old and older portions of the tree; consequently the trees have a tendency to confine fruit production to the outer parts of the tree, and long branches devoid of both fruit and foliage are the rule back of the one-year-old wood. A careful examination of trees making a short annual growth will show that practically all of the lateral buds on the previous season's growth produce blossoms and later fruits. Consequently there is little opportunity for lateral twig and spur development. The general tendency of trees with fruiting habits similar to the sour cherry is to produce lateral fruit buds near the tip of shoots of the current season's growth and lateral leaf buds which later develop into lateral branches or spurs near the base of these shoots. However, if the annual twig growth is short, there is a tendency for the lateral fruit buds to develop all the way along the growth, and leaf buds (to form spurs and lateral growths) are not produced. Thus it seems that any treatment that will induce longer growths is desirable. Nitrogenous fertilizers and better cultural practices will lead to quicker and better results than cutting-back to induce growth.

PRUNING THE PLUMS

European Plum—The type of training recommended for apple trees is in general satisfactory for the European plums. They may, however, be headed slightly lower. Also less cutting should usually be practiced because of the strong tendency of some varieties to produce excessive growth.

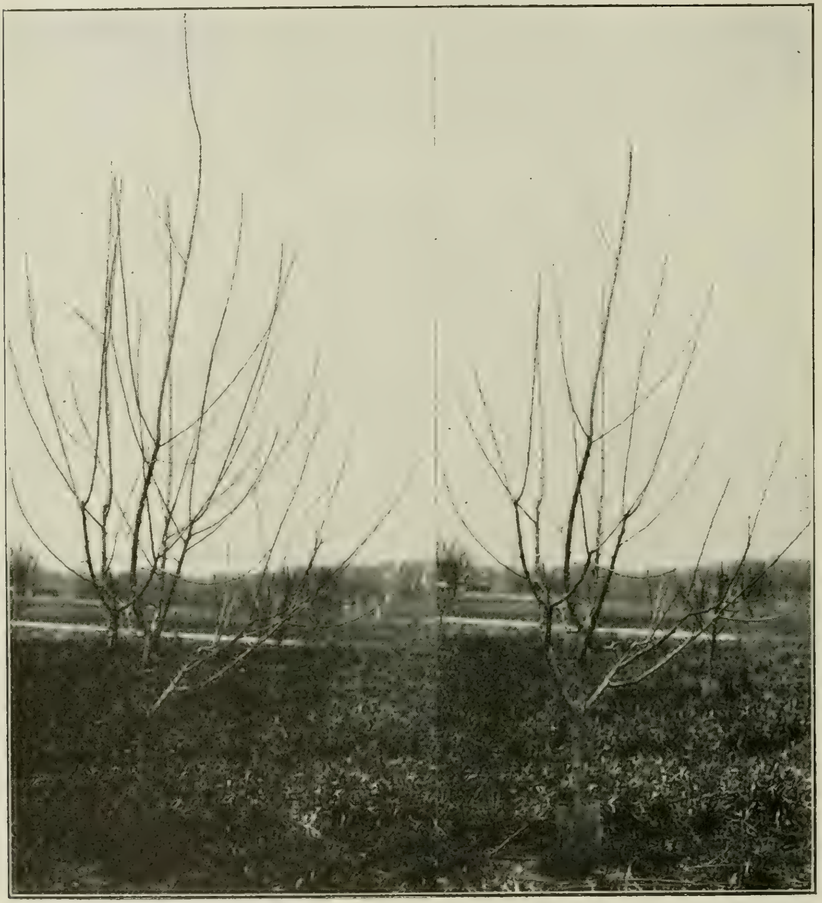


FIGURE 37. A vigorous three-year-old European plum before and after pruning. It is being developed as a modified leader tree. Note relative amounts of heading back for the leader and other branches

Heavy heading-back of bearing European plums may result in high trees with dense tops; hence, heading back, when advisable, should be light. The general treatment of bearing plums should be such as will invigorate the spurs, keep the tops properly thinned out and in good shape, and prevent crossing and interfering branches. Thus, thinning about the outer parts of the trees (removing small rather than large branches) as recommended for apple trees should largely suffice.

Japanese Plums—The Japanese plums should be trained as open center trees and handled in a manner similar to that of training and pruning peach trees, except that less cutting back is advisable. Since they bear much of their fruit laterally on the previous season's growth, some annual heading back of the previous season's growth, but less than that usually given the peach, is desirable. However, it must be remembered that considerable fruit is also borne on spurs similar to those of the properly functioning cherry, which means that while the pruning, in general, is similar to that for the peach, yet there should be an approach toward that for the sour cherry.

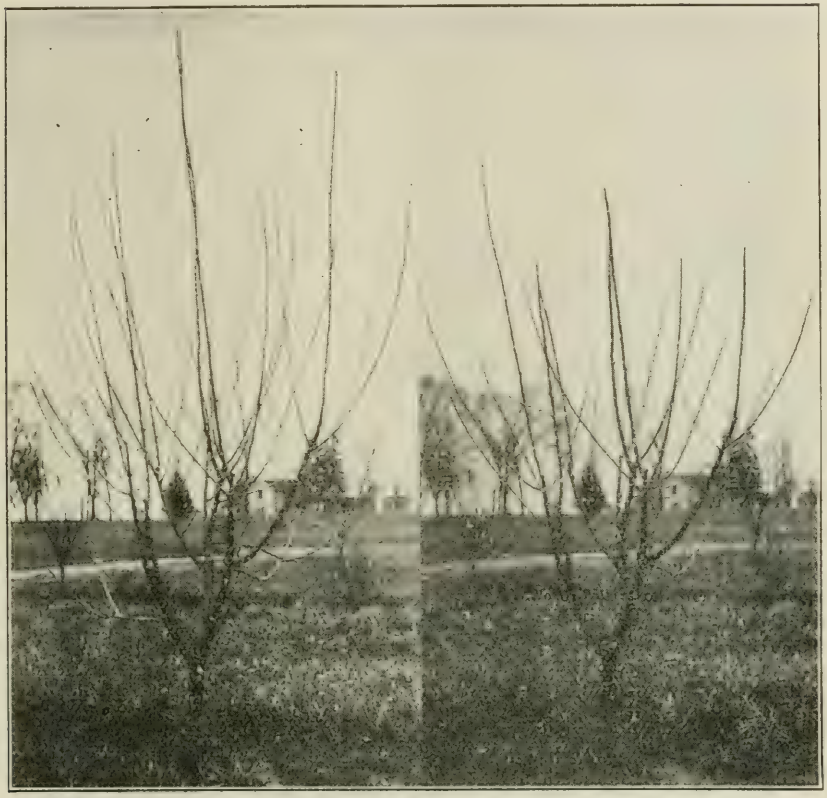


FIGURE 38. Another three-year-old European plum with open center system of training. Because of the tendency for the portion of the tree on the right side to outgrow that on the left, the former was cut back heavily and the latter very lightly; in fact, it was left longer than the right portion of the tree because of the much smaller size of the branches.

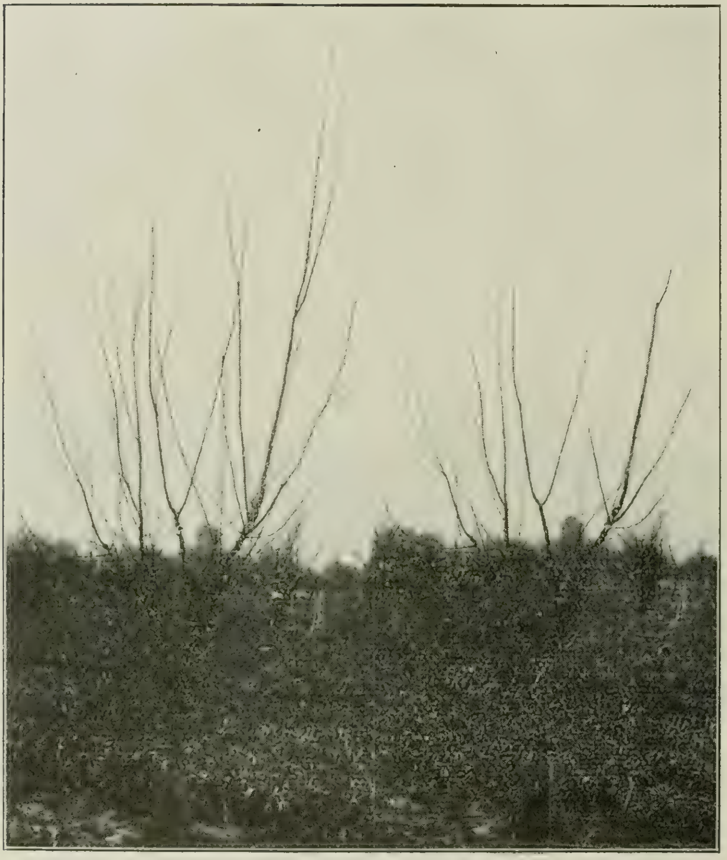


FIGURE 39. A three-year-old Japanese plum tree in which one side of the tree has decidedly outgrown the other, making it rather difficult to handle. Another pruning, a year later, will be required to restore balance. Note that the branch on the right was cut back to a point near the base of the last season's growth, a practice that is seldom justified.

STUDIES ON ACTIVE BASES AND EXCESS ACIDS IN MINERAL SOILS*

Technical Bulletin No. 57

BY C. H. SPURWAY

INTRODUCTION

In 1917 the author published a short article (Spurway 9) showing a relationship between the proportion of calcium to iron and aluminum soluble in 0.2 HCl and the soil reaction. Acid soils gave proportions of CaO : Fe_2O_3 + Al_2O_3 above 1 : 1.3 and alkaline soils proportions below this figure. These results indicate that soil calcium is the principal element contributing to the basicity of soils and that the iron and aluminum are concerned with soil acidity; that is, in combination as a portion of the acid radical of soil salts. In a subsequent publication (Spurway 8) it was shown that the quantity fixation of cations of neutral salts by soils depended upon the quantity of soil bases in a condition to react with the neutral salts. Also, that anions of chemical salts were fixed by soils when they formed insoluble compounds with soil bases. Pursuing the general problem effects of fertilizer salts on soils, it was considered advisable to devise methods for determination of active soil bases and acids, if possible, in order to define more closely the reactions between soils and fertilizers on a quantity basis, as well as the effects produced by fertilizers on the composition and reaction of soils.

As it is known that soil materials may be classified as partly active and partly inert, and that the active substances of soils are largely in an insoluble condition; and also, that the hydrogen electrode may be used to determine the neutralizing values of solids, it was assumed that the hydrogen electrode could be of value in determining the neutralizing value of soils for acids and bases, and hence the basicity and acidity of soils on a quantitative basis.

Attention is here called to the use of the term active bases in this publication, which is intended to mean soil bases neutralized by acids excepting iron and aluminum.

---

*Presented to the Director for publication July 19, 1922.

APPARATUS

The electrometric titration apparatus used for this work consisted of the following named units connected as illustrated in Fig. 1.

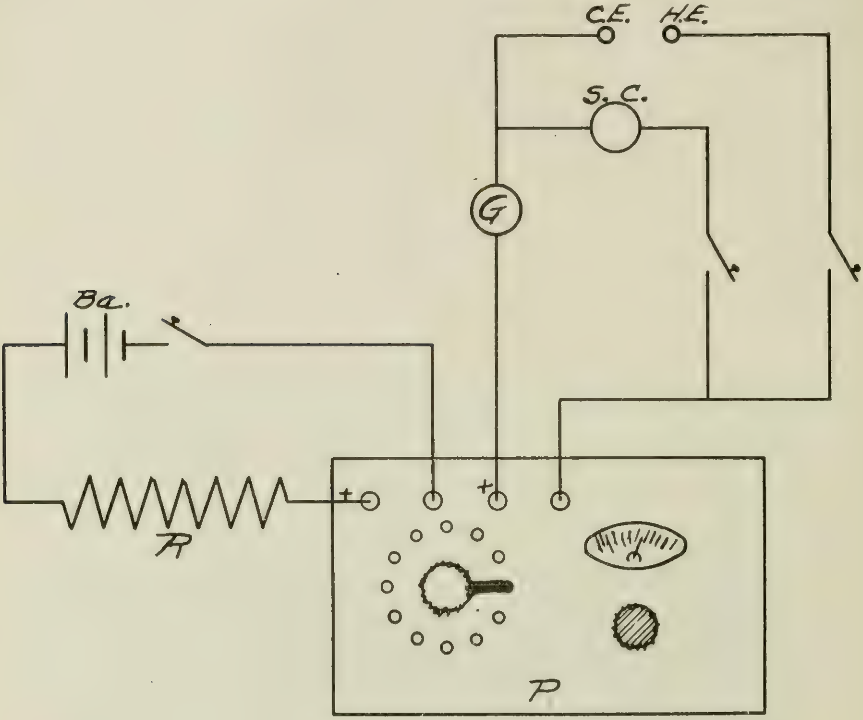


Fig. 1.—Diagram showing arrangement of apparatus.

Fig. 1—P—Leeds and Northrup Students' Potentiometer
R—Plug Resistance, 11, 110 ohms capacity
Ba—2 Columbia Dry Cells
G—Galvanometer, D'Arsonval, wall type
S. C.—Weston Standard Cell
C. E.—Wendt's Calomel Electrode Vessel
H. E.—Wendt's Hydrogen Electrode

Jelly tumblers were used for containers for hydrogen ion concentration determinations on the materials under investigation. Covers of these containers were coated with parafin and used to prevent evaporation and contamination of the solutions during the time of standing. Stirring was accomplished by means of a bent glass rod actuated by a Cenco Friction Drive, Variable Speed, Motor Stirrer with a flexible shaft. Hydrogen was generated from C. P. stick zinc and hydrochloric acid and washed through a solution of potassium hydroxid and pyrogallic acid and finally through distilled water. The flow of hydrogen was regulated with a Hoffman pinch cock. An elevated bottled containing distilled water was connected to the jacket of the hydrogen electrode to facilitate the washing of the electrode. The hydrogen and water connection was made by means of a three way, glass stopcock. The calomel electrode vessel was supplied with a normal solution of potassium chloride, saturated with calomel, from an elevated bottle and the supply regulated with a Hoffman pinch cock attached to the connecting rubber tubing. The electrodes and stirring apparatus were mounted on a large ring support for convenience in operating.

Preparation of the hydrogen electrode consisted of coating it with platinum black by electrolyzing a dilute platinic chloride solution for about two minutes time and then electrolyzing a dilute solution of sulfuric acid to saturate the platinized electrode with hydrogen. Two dry cells in series were used for this work and the electrode connected to the negative pole. Contact through the liquids to the positive pole of the batteries was made by a small piece of platinum wire attached to a copper wire. When not in use the hydrogen electrode was kept submerged in distilled water.

Calomel for the calomel electrode was prepared by the chemical method recommended by Ellis, cited by Knight (5), and the cell made up according to standard methods.

METHOD OF OPERATION

After considerable experimentation with varying quantities of soils and water and various ways of handling the apparatus to determine the pH value of the solutions, the following method was selected as one designed to cover the desired range of conditions and give the most reliable results. In the titration work, 10 gms. of soil was placed into each of several tumblers, the number depending on the range to be covered. O.1 N equivalents of the different reagents used were added in steps ranging, usually, from one to 10 cc. and sufficient neutral, distilled water was added to each tumbler to raise the liquid volume to 50 cc. Variations in soil quantities and volumes of liquid are noted when they occur, as are other changes from the usual procedure. The pH was determined on these solutions at various times depending on the nature of the titration.

The hydrogen electrode, after preparation and thorough washing with distilled water, was placed into the soil suspensions always to the same depth, and the flow of hydrogen over it regulated to the rate of about two bubbles a second. The electrode remained in the suspensions constantly, except during the change from one to another, and the stirring was continuous. The speed of the stirrer was adjusted to keep all soil particles in motion. At the beginning of a titration, the hydrogen electrode was always brought to equilibrium with an untreated soil suspension. Change to other suspensions was made in order, and without washing the electrode.

The salt arm of the calomel vessel was introduced into the soil suspension immediately before reading the voltage and at the same distance from the hydrogen electrode and removed directly after completing the reading. A few drops of the potassium chloride solution were passed through the salt arm of the calomel electrode before and after each reading to flush out engaged soil particles and allow contact with the soil solution with a fresh portion of the potassium chloride.

Calibration of the potentiometer consisted in setting the indicators to read the same voltage as given for the standard cell and adjusting resistance R until no deflection was observed in the galvanometer with the cell circuit momentarily closed. Rough adjustment was first made with a normal calomel cell, and final calibration with the Weston Standard Cell. The potentiometer then read in volts and was adjusted before each titration. After starting the apparatus for each determination, potential readings were taken at five minute intervals until the change in potential over the last reading was constant within one millivolt. Fifteen to forty-five minutes time was usually required to complete a determination. Voltage readings were converted to pH factors by means of the Schmidt and Hoagland conversion tables (6). The author is indebted chiefly to Clark (1) and Hildebrand (3) for the theory and applications of the hydrogen electrode.

SOILS AND REAGENTS

The neutralizing values of four acid soils—a medium sand, sandy loam, silt loam and clay loam—were studied using the hydrogen electrode, in the manner described, as an end point indicator. These soils were air dried and passed through a two millimeter mesh sieve. Results of this experimentation are shown in the curves, Figs. 2 to 9 inclusive. As indicated under the heading, Method of Operation, the titrations were set up in a series of units in order that pH readings might be taken at regular intervals of time. The reagents used were $Ca(OH)_2$, Al_2Cl_6 and HCl, and these reagents were added in 0.1N equivalents so that all the curves might be plotted on the same scale. Curves are shown in two groups containing four figures in each group, Figs. 2, 3, 4 and 5 comprise the first group and Figs. 6, 7, 8 and 9 the second. All alkali titrations were made with $Ca(OH)_2$ and the second group of alkali titration curves were duplications of the first group. The acid titrations shown in the first group of four figures were made with $Al_2 Cl_6$, and in the second group with HCl.

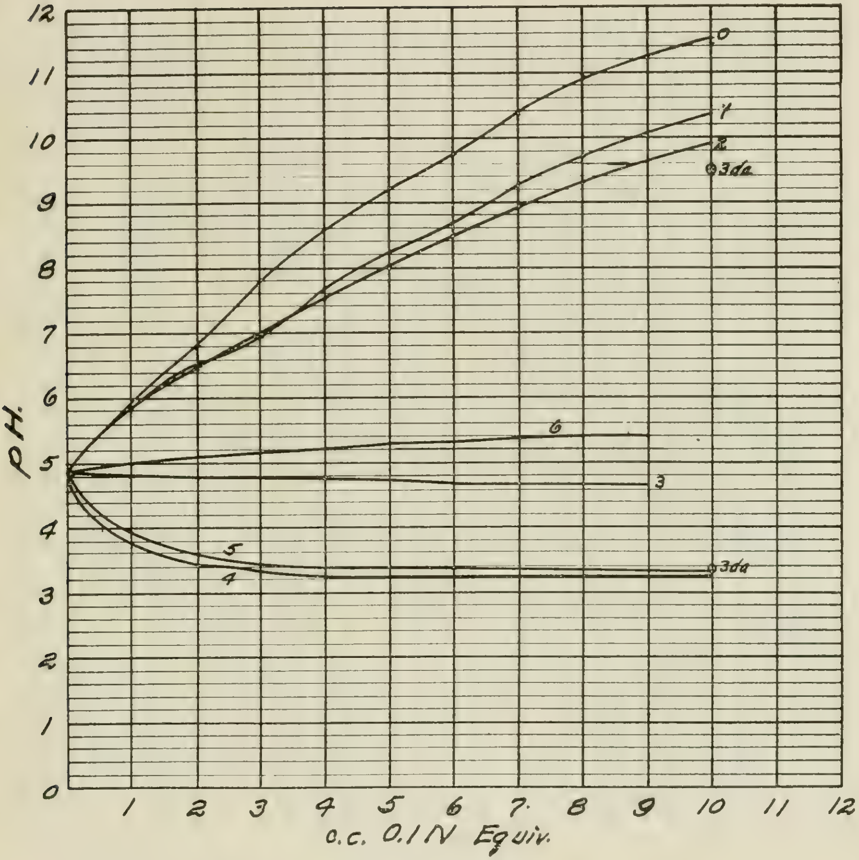


Fig. 2 Titration curves—medium sand soil.
Curve No. 0. Initial titration curve, $Ca(OH)_2$
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with Al_2Cl_6.
" No. 4. Initial titration Curve, Al_2Cl_6.
" No. 5. After standing one day, Al_2Cl_6.
" No. 6. Back titration of Al_2Cl_6 series with $Ca(OH)_2$.

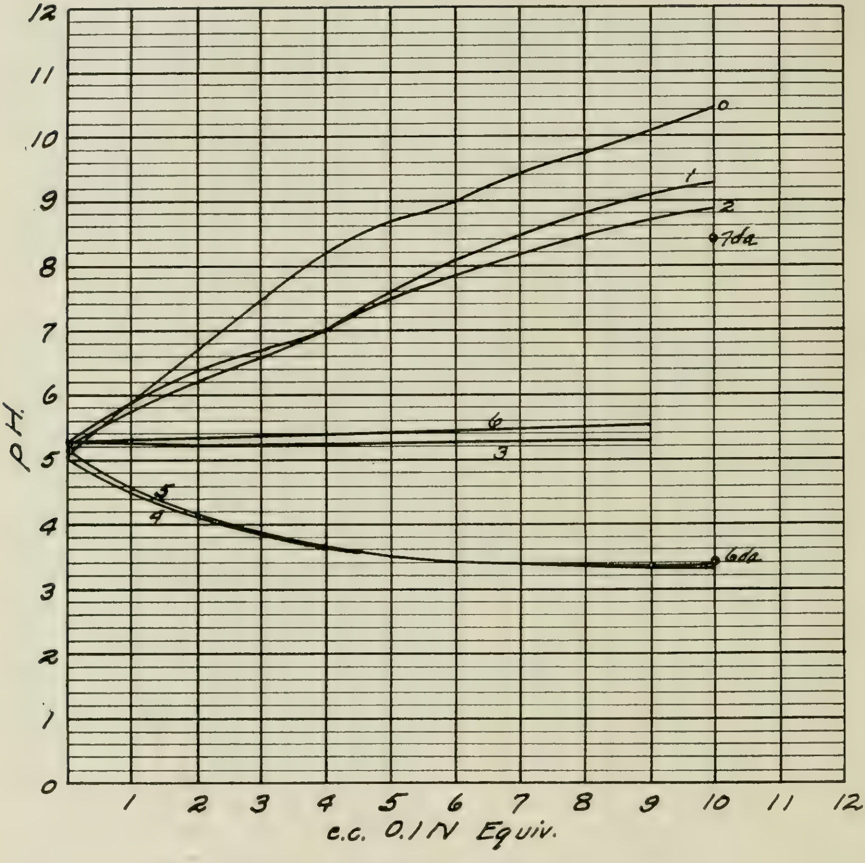


Fig. 3.—Titration curves—sandy loam soil.
Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with Al_2Cl_6.
" No. 4. Initial titration curve, Al_2Cl_6.
" No. 5. After standing one day, Al_2Cl_6.
" No. 6. Back titration of Al_2Cl_6 series with $Ca(OH)_2$.

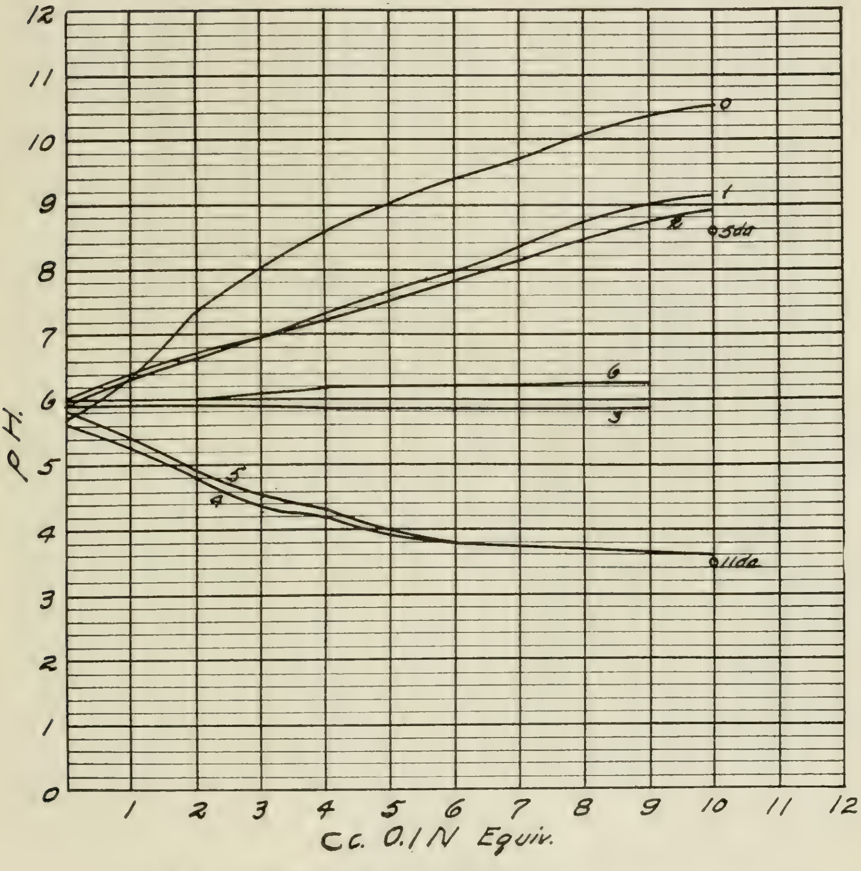


Fig. 4.—Titration curves—silt loam soil.
Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with Al_2Cl_6.
" No. 4. Initial titration curve, Al_2Cl_6.
" No. 5. After standing one day, Al_2Cl_6.
" No. 6. Back titration of Al_2Cl_6 series with $Ca(OH)_2$.

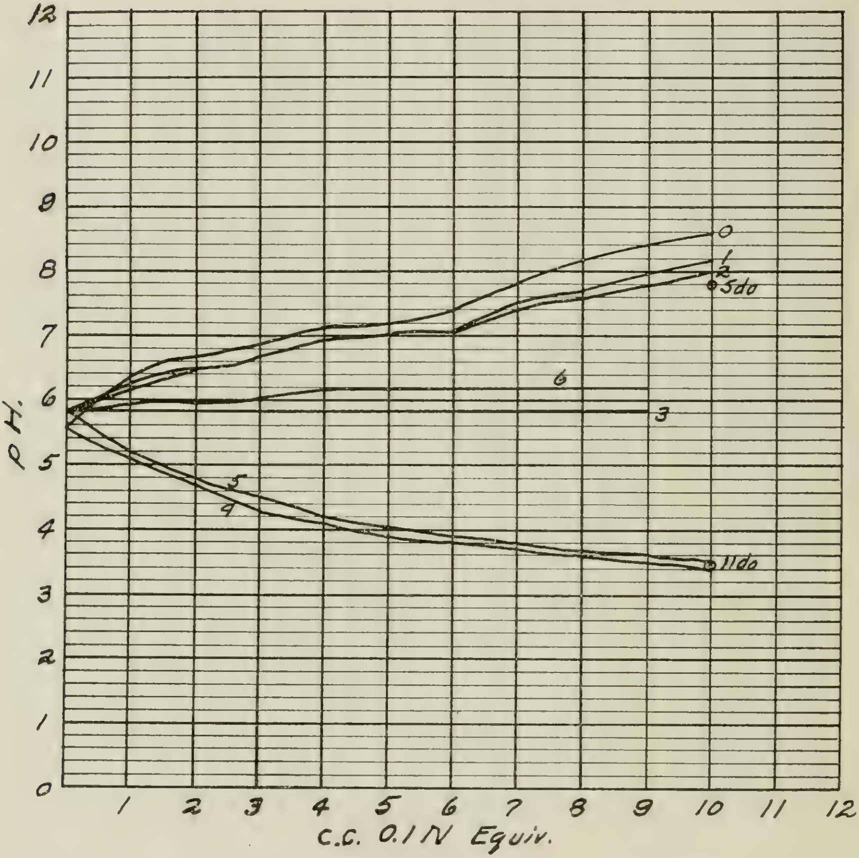


Fig. 5.—Titration curves—clay loam soil.

Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with Al_2Cl_6.
" No. 4. Initial titration curve, Al_2Cl_6.
" No. 5. After standing one day, Al_2Cl_6.
" No. 6. Back titration of Al_2Cl_6 series with $Ca(OH)_2$.

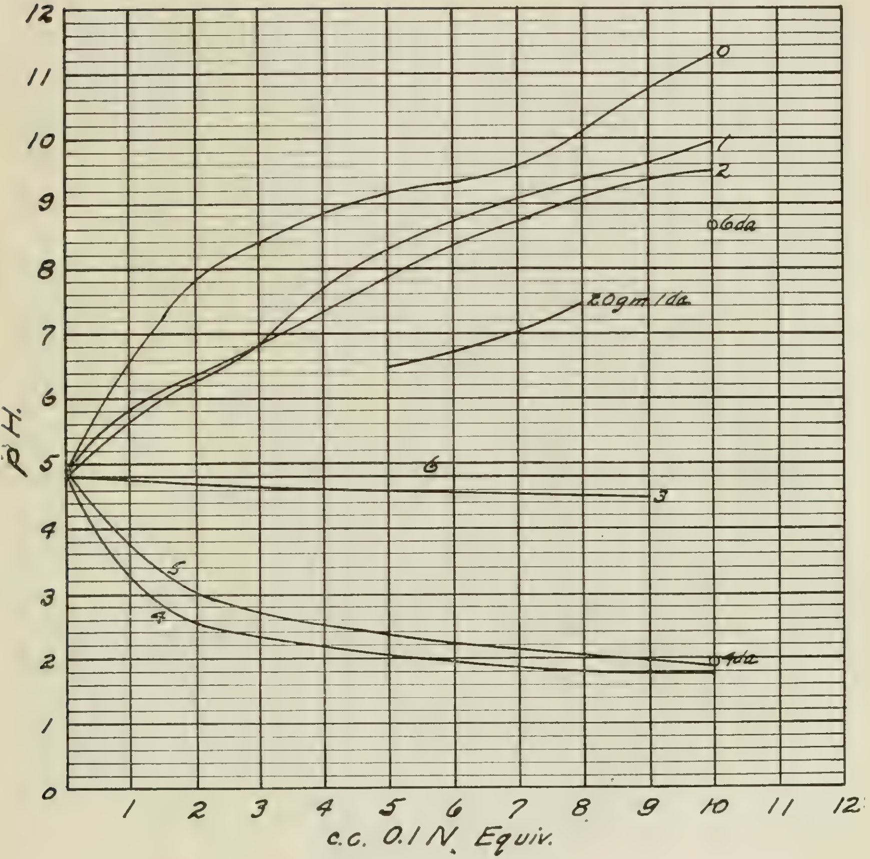


Fig. 6.—Titration curves—medium sand soil.
Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with HCl.
" No. 4. Initial titration curve, HCl.
" No. 5. After standing one day, HCl.
" No. 6. Back titration of HCl series with $Ca(OH)_2$.

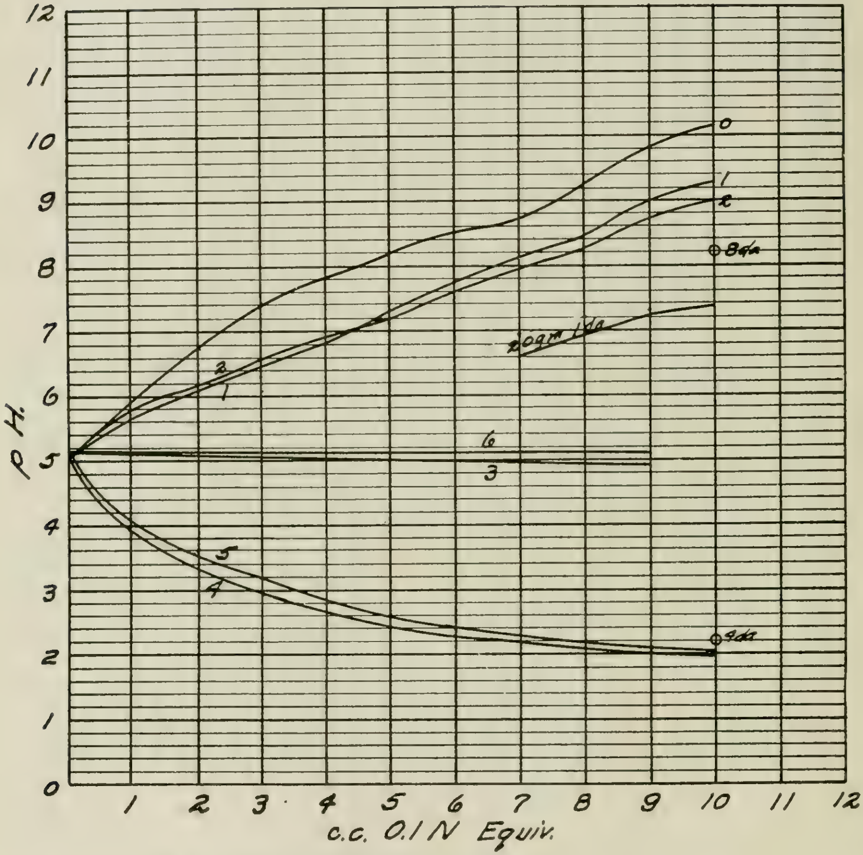


Fig. 7.—Titration curves—sandy loam soil.
Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with HCl.
" No. 4. Initial titration curve, HCl.
" No. 5. After standing one day, HCl.
" No. 6. Back titration of HCl series with $Ca(OH)_2$.

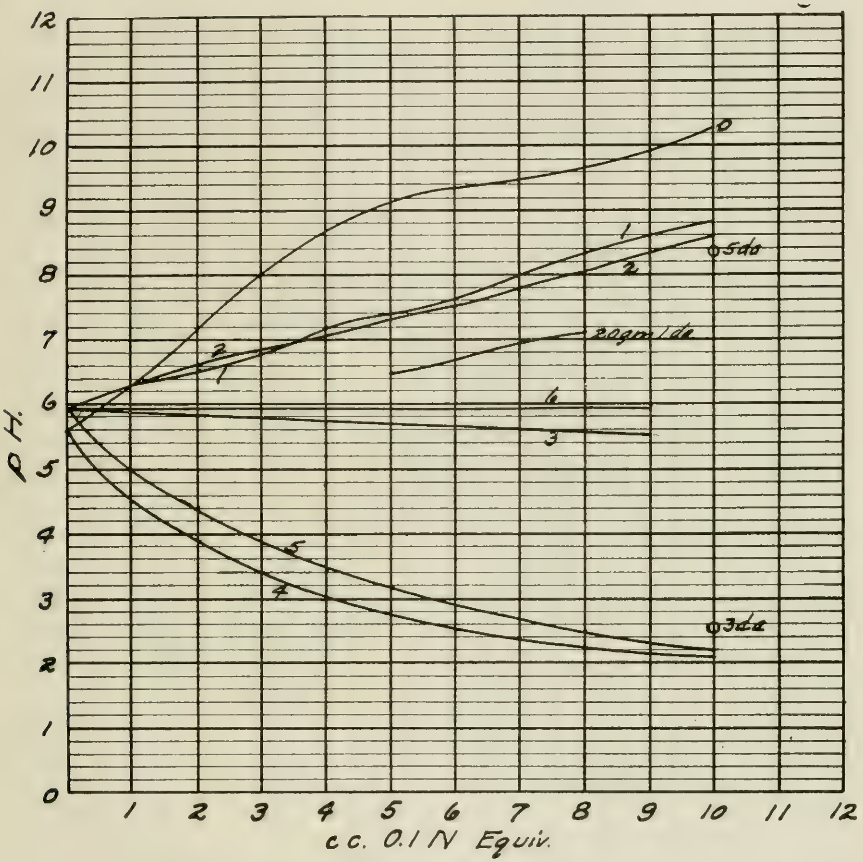


Fig. 8.—Titration curves—silt loam soil.
Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with HCl.
" No. 4. Initial titration curve, HCl.
" No. 5. After standing one day HCl.
" No. 6. Back titration of HCl series with $Ca(OH)_2$.

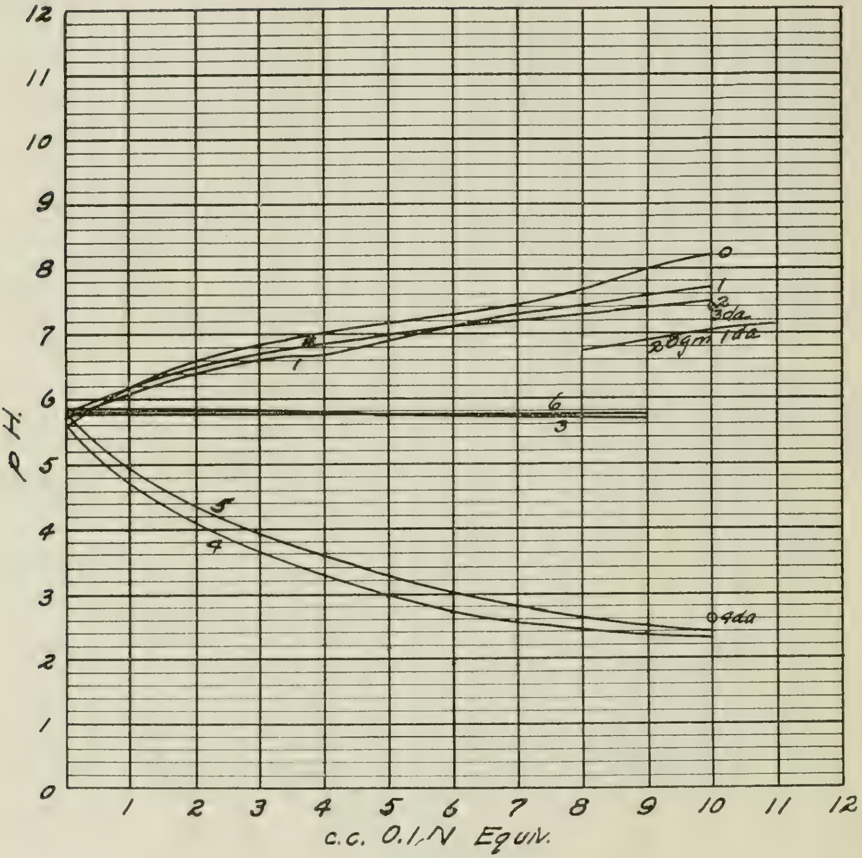


Fig. 9.—Titration curves—clay loam soil.

Curve No. 0. Initial titration curve, $Ca(OH)_2$.
" No. 1. After standing one day, $Ca(OH)_2$.
" No. 2. After standing two days, $Ca(OH)_2$.
" No. 3. Back titration of $Ca(OH)_2$ series with HCl.
" No. 4. Initial titration curve, HCl.
" No. 5. After standing one day, HCl.
" No. 6. Back titration of HCl series with $Ca(OH)_2$.

INITIAL ALKALI TITRATION CURVES

In obtaining the first group of four No. O curves the whole titration series was first set up and the pH values then determined, which required nearly four hours time for completion. The second group of four No. O curves illustrate the results obtained from reading each unit as soon as possible after bringing the $Ca(OH)_2$ in contact with the soil. The observable difference in these two groups of curves is that the second group shows marked buffering midway of the curves, which may indicate the formation of a calcium salt. Points in these curves, however, can not be considered definite, as the reaction between soil and $Ca(OH)_2$ progresses rapidly in the beginning. These curves are useful in making comparisons between them and the other alkali titration curves.

ALKALI TITRATION CURVES NOS. 1 AND 2

As may be observed, these curves run closely together below pH 7.00. Curves No. 2, however, occupy a position slightly above curves No. 1 below the neutral point; but they cross in the vicinity of pH 7.00 and lie below curves No. 1 above this point. The fall in pH shown by these alkali titration curves is considered due to the disappearance of hydroxyl ions, indicating that above the neutral point the reaction is still in progress. The slight rise in pH below the neutral point, shown by curves No. 2, may be due to increased hydrolysis of soil compounds. This phenomenon was also observed in the untreated soils and in the acid titrations before the point of complete neutralization of soil bases. pH readings on the No. 10 units taken at later periods than two days are also shown on the graphs. These results seem to show that the reaction on the acid side of the titration is practically complete in one day; but in the presence of an excess of hydroxyl ions, it is continuous over a long period of time.

Since the pH readings for the alkali titration curves were made in open containers, it was thought necessary to check the results with another experiment using $Ca(OH)_2$ and water without soil in alkali concentrations representing excess of alkali over that required to bring the soils to pH 7.00, in order to determine the effect of CO_2 absorption from the air. This experiment was conducted in the same manner as those for the soil—$Ca(OH)_2$ titrations except the soil quantities were left out. The results are illustrated in Fig. 10. An examination of these curves will show: (1) that the pH fell more rapidly in the dilute solutions than in the more concentrated solutions, and (2) the rate of fall in pH increases with time. These results are opposed to those obtained when soil is present in the determinations; hence, it is assumed that the soil—$Ca(OH)_2$ results are not due to absorption of CO_2 from the air.

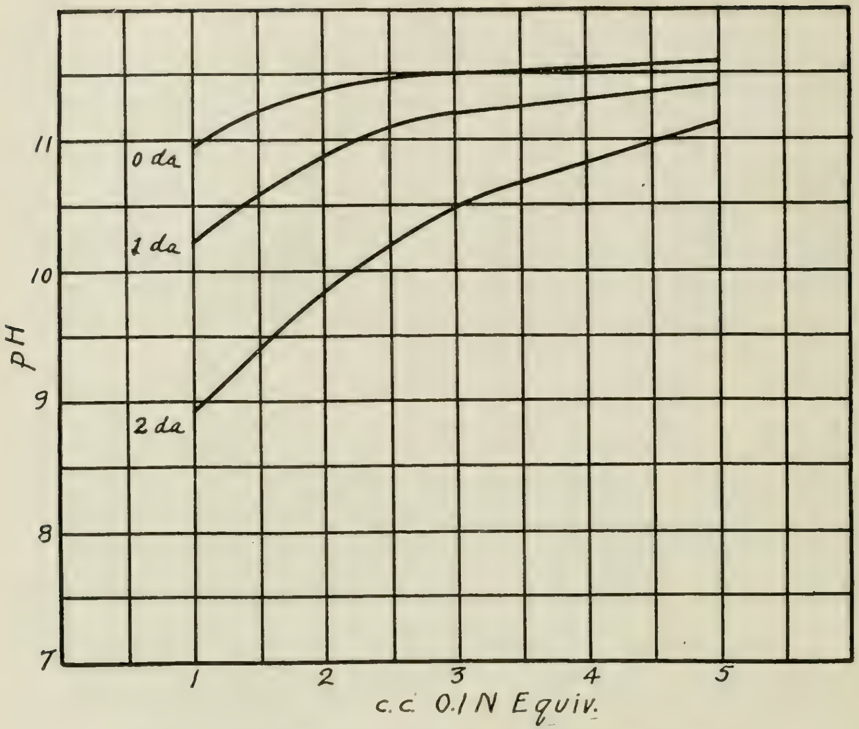


Fig. 10. Curves showing pH readings of Ca $(OH)_2$ solutions without soil.

ACID TITRATION CURVES NOS. 4 AND 5

The first group of acid titration curves were obtained by using Al_2Cl_6 and the second group by HCl. 5 gms. of the clay loam soil was used in the acid titrations because this soil had a high neutralizing value for acids as compared to the other soils. No. 4 curves were initial titration curves, and No. 5 curves were drawn on readings taken after one day's standing. The Al_2Cl_6 curves have the same general trend as the HCl curves, but the Al_2Cl_6 one and two day curves lie closer together than those obtained with HCl. Another point of difference in these two groups of curves is that the pH runs lower in case of the HCl titrations, which is probably due to the greater dissociation of HCl at the concentrations used. It is not clear, at present, why these curves should have this form. Several reactions were undoubtedly taking place; neutral salts of calcium and magnesium and in smaller quantities of potassium and sodium were formed, acid salts of iron and aluminum were added or formed, weak acids were split off from soil salts, and in case of the HCl titrations, hydrogen ions were added. In addition to the foregoing, other reactions might have taken place. Perhaps the only statement that may be reasonably made in this connection is that.

the acid curves represent the resultant concentrations of hydrogen ions of the several reactions involved. Points obtained from the No. 10 units taken at later periods than two days are indicated on the graphs. An important conclusion that may be drawn from these acid curves, and one bearing on the object of this experimentation, is that in presence of an excess of acid reagent the soil acid reaction goes to a certain point and remains quite constant for several days, at least so far as may be determined by measuring the concentration of hydrogen ions. If this be true, then the line of separation between the more soluble soil bases and the insoluble soil bases is quite marked and the quantity of active or easily soluble soil bases may be quite accurately determined by direct titration with dilute, strong acids. This point will be taken up again later under methods for determining active bases and excess acids in soils.

BACK TITRATION CURVES NOS. 3 AND 4

The alkali back titrations were all made with $Ca(OH)_2$, but the acid back titrations shown in the first group of curves were made with Al_2Cl_6 and in the second group with HCl. In performing these back titrations a quantity of acid or alkali equivalent to the previous treatment was added to each unit, and the volume of the liquid in each unit was increased above 50 cc. by the volume of the reagent used. In case of the back titrations with acids, the volume increases from 50 cc. to 59 cc. over the series, but with the alkali, from 50 cc. to approximately 73 cc. because in the latter case more of a saturated solution of $Ca(OH)_2$ was required to equal the 0.1 N equivalent. Evidence will be introduced later to show that this increase in volume could have had only a slight effect on changing the pH of soil suspensions. Gillespie and Hurst (2), and Sharp and Hoagland (7) have also published data to this effect. Allowing for changes in pH produced by volume increases, changes in hydrolysis and solubilities, it may be said that in these back titrations the pH comes back closely to that of the untreated soils. Apparently the $Ca(OH)_2$, wholly or in part, forms salts with weak soil acids and these salts may be back titrated closely to the point of chemical equivalence with strong acids.

Considering the acid titrations, salts were formed with soil bases, but a quantity of alkali equivalent to the acid used in the initial treatments brought the pH of the mixtures closely to that of the untreated soils. The acid salts formed might be back titrated, but it would be difficult to account for the quantities of alkali used equivalent to the neutral salts formed unless it were assumed that in forming these neutral salts, soil bases were split off from weak acids and these acids took up the alkali in the back titrations.

THE TEMPERATURE FACTOR

Temperature control was not provided for individual determinations. An attempt was made, however, to control the temperature within certain limits of the room in which the work was done by regulating the ventilation. This room was situated on the north side of a brick building and its air temperature as measured by a thermometer suspended near the hydrogen electrode apparatus, rarely varied more than one degree from 25°C during measurements. Since the temperature corrections are small in magnitude in hydrogen ion concentration measurements, and since errors of duplication on soils are often greater than those introduced by small temperature changes, it is thought that conclusions drawn from this experimental work will not be changed by introducing the temperature correction values.

END POINT AND TIME FACTORS

There are indications of a slight buffer action below pH 7.00 best seen in curves No. 1. Also, a slightly greater rise in pH may be observed in the vicinity of pH 7.00. Although soil acids are weak in their effects and can not be expected to give distinct end points this may be considered some evidence of salt formation between soil and $Ca(OH)_2$ with an end point slightly above pH 7.00, indicating the possibility of the formation of a salt of calcium with a weak soil acid. While pH 7.00 has been used as the point of neutralization in this work, it is believed that the true end point of this reaction lies slightly above pH 7.00. The buffering effects shown in the second group of alkali titration curves indicate that other end points might be obtained were the titrations carried further.

In order to test the permanence of the pH in the units lying nearest pH 7.00 readings were taken after 14 days standing and these readings were close to the original ones. A quantity of $Ca(OH)_2$ equivalent to 3.1 cc. 0.1 N alkali was added to 10 gms. of the medium sand soil together with sufficient water to make the total volume of liquid 50 cc. and this soil required 7½ hours of constant stirring to bring the pH down to the neutral point. In view of these and preceding results it seems that at least a day's time is required to complete the reaction between soil and $Ca(OH)_2$ below pH 7.00.

METHODS FOR DETERMINING ACTIVE BASES AND EXCESS ACIDS IN SOILS

Methods for determining the quantity of soil bases other than iron and aluminum that will react with dilute HCl, and of soil acids in acid soils in excess of the quantity of soil bases were devised based on the foregoing experimental results. The active bases were measured by the quantity of 0.2 N HCl neutralized by 20 gms. of soil; and the exvess acids measured by the quantity of $Ca(OH)_2$ required to bring the soil to pH 7.00 by indirect titration, using 0.1 N equivalents of $Ca(OH)_2$ and 10 gms. of soil and the hydrogen electrode as an end point indicator.

Method For Determining Active Bases In Soils.—20. gms. of air dry soil were placed into an 8 oz. sterilizing bottle and 50 cc. of 0.2 N HCl added. The bottle and contents were shaken in a machine for three hours. The solution was then separated from the soil mass by filtration and 25 cc. drawn from the filtrate, boiled to expel CO_2, and titrated for excess of acid with a 0.2 N KOH solution, using brom thymol blue as the end point indicator, to a faint blue color. When the precipitate of iron and aluminum hydroxides was voluminous it was found necessary to proceed with caution in titrating when near the end point and to allow the precipitate to settle in order that the color of the dye could be observed in the clear solutions. The quantity of HCl neutralized by the soil bases is determined by difference and its equivalent in bases computed as calcium. For soils containing carbonates it was necessary to use quantities smaller than 20 gms. depending on the amount of carbonates present.

Method For Determining Excess Acids In Acid Soils.—10 gms. of air dry soil were placed into each of several 8 oz. sterelizing bottles, the number depending on the range to be covered to pass the neutral point. 0.1 N equivalents of $Ca(OH)_2$ were added to the soil portions, in steps increasing by 1 cc. in magnitude, with sufficient neutral, distilled water to make the solution total 50 c.c. The bottles were then shaken four hours and allowed to stand one day. After standing, the pH of the series was determined, a curve plotted using pH as ordinates and cc. of 0.1 N equivalents as abscissae, and the quantity of $Ca(OH)_2$ required for neutralization determined from the curve to 0.1 cc. of 0.1 N equivalent.

These methods were used on 10 and 20 gm. portions of the four soils under experimentation in order to check on different quantities of soil. Results for active base determinations are given in Table 1 and those for excess acids are plotted with the second group of curves. It may be seen from these results that good checks were obtained.

The 20 gm. portions of soil used in the foregoing experiment were washed until the leachings were free from chlorine and the method repeated on them. These results are given in Table 1 in the column, HCl neutralized after drying. On the average only about 3.4 per cent more bases were obtained in the heavier soils. Assuming that the more insoluble soil materials hydrolyze, these results are to be expected.

Table 1.—Quantities of HCl neutralized by different amounts of soils. Results in cc. 0.2 N HCl.

Weight of soil....	10 gms.			20 gms.			
Time of shaking..	1 hr.	2 hr.	3 hr.	1 hr.	2 hr.	3 hr.	HCl neutralized after drying
Medium sand....	1.2	1.2	1.2	2.4	2.4	2.4	0.0
Sandy loam......	2.6	2.6	2.6	5.2	5.4	5.4	0.2
Silt loam.........	6.0	6.0	6.0	12.2	12.2	12.4	0.4
Clay loam.......	9.2	9.2	9.0	17.6	17.6	17.8	0.6

EFFECT OF VOLUME OF SOLUTION

It was considered advisable to check pH determinations on different volumes of solution. These results are presented in Table 2, in comparison with those obtained by the method previously defined. There is a tendency toward a somewhat higher pH value in the solutions of greatest volume, although this tendency is not well marked.

Table 2.—Effect of volume of solution—treated and untreated soils. 10gms. of soil.

	cc. Ca(OH)$_2$	0.1 N equiv.	pH		
			50 cc.	75 cc.	100 cc.
Medium sand	....	....	4.85	4.82	4.90
" "	7.9	3.1	7.00	6.98	7.17
Sandy loam	....	....	5.11	5.16	5.19
" "	10.7	4.2	7.00	6.97	7.12
Silt loam	....	....	5.95	5.80	5.87
" "	8.5	3.35	7.00	7.05	7.05
Clay loam	....	....	5.83	5.82	5.80
" "	12.7	5.00	7.00	7.13	7.10

APPLICATION OF FOREGOING METHODS

A series of soils was selected covering a range in pH from 4.73 to 8.12 and the foregoing methods for active bases and excess acids applied to them in order to determine the possible correlations. These results are given in Table 3, and show, apparently, an important relationship between the base—acid ratio and the pH of the soils. Since only the total quantities of bases and acids are determined, the results are given in terms of calcium equivalents. Quantities of total active acids were obtained by adding results for active bases to those for excess acids, assuming that the active bases were combined with an equivalent of active acids. These results may also be considered a check on the accuracy of the methods.

Table 3.—Showing relationships between active soil bases, acids and pH. Results in lbs. expressed as lbs. calcium to 2,000,000 lbs of soil.

Soil Class	Active alkali earth bases (b)	Excess acids	Total active acids (a)	b/a ratio	pH	Lime requirement lbs. CaCO$_3$
Sandy loam	800	1,120	1,920	0.42	4.73	2.800
The medium sand	960	1,240	2,200	0.44	4.85	3,100
Loam	1.840	1.800	3,640	0.51	4.94	4,500
The sandy loam	2,160	1,680	3,840	0.56	5.11	4,200
Sandy loam	4,160	3,000	7,160	0.58	5.24	7,500
Sandy loam	3,280	1,720	5,000	0.66	5.44	4,300
Medium sand	1,760	880	2,640	0.67	5.48	2,200
Medium sand	2,400	1,040	3,440	0.70	5.50	2,600
Silt loam	2,960	960	3,920	0.76	5.65	2,400
Medium sand	1,040	280	1,320	0.79	5.78	700
The clay loam	7,120	2,000	9,120	0.78	5.83	5,000
The silt loam	4,960	1,340	6,300	0.79	5.95	3,350
Fine sand	5.520	1,400	6,920	0.80	6.00	3,500
Silt loam	6,560	960	7,520	0.87	6.39	2,400
Clay loam	9,840	560	10,400	0.95	6.66	1,400
Silt loam	12,480	....	12,480	1.00	7.02	....
Silt loam	11,120	....	....	....	7.61	....
Sandy loam	5,360	....	....	....	7.86	....
Medium sand (limed)	7,360	....	....	....	7.93	....
Clay (subsoil)	233,600	....	....	....	8.12	....

It may be observed from Table 3 that, according to these methods, there are no direct relationships shown between soil class, active bases, excess acids and pH. The term lime requirement refers in this case to the quantity of calcium as $Ca(OH)_2$ required to neutralize 2,000,000 lbs. of soils and expressed as lbs $CaCO_3$.

Reference is here given to the work of Swanson, Latshaw and Tague (10) who state that the quantity of $Ca(OH)_2$ necessary to raise the pH of soils to a definite point does not depend on the pH of the untreated soils, and that the quantity of soil calcium soluble in dilute acids, or the total soil calcium, is not related to the pH of Natural soils.

A direct relationship, however, was found to exist between the base-acid ratio and pH, below the neutral point. A logical conclusion to be drawn from these results is that the pH of soils, or the concentration of hydrogen ions, is controlled by the proportion of active soil bases to the active soil acids. This is not a direct proportion between the pH and base-acid ratio as is shown by the curve in Fig. 11, where pH is plotted against base-acid ratios; but the concentration of hydrogen ions decreases more rapidly above pH 4.00 as the quantity of active bases becomes greater in proportion to the quantity of active acids. This curve is typical of hydrogen ion titration curves obtained by titrating weak acids with alkalis and strongly supports the conclusion previously given that $Ca(OH)_2$ and other alkalis may form salts with soil acids.

The first point on the curve in Fig. 11 was determined in the following manner: 20 gm. portions of the four soils were treated with an excess of a 0.2 N acid solution of Al_2Cl_6, shaken for three hours, washed until washings were free from chlorine and the pH determined in the regular manner. The results found were: Medium sand pH 4.06, sandy loam pH 4.06, silt loam pH 3.92, and clay loam pH 3.96. Since the pH was nearly the same on the four soils after their active bases had been leached from them, it was assumed that the average of these figures, pH 4.00, was close to the pH of the soil acids, and this point was plotted on the curve in order to compare with the other points given.

It may also be seen from Table 3 that when either the quantity of active bases or the quantity of excess acids is known the other may be computed by using the base-acid ratio and pH factors. Points on the curve in Fig. 11 are determined on a series of different soil classes taken from various soil formations and when these differences are considered the correlation between base-acid ratio and pH seems remarkable, unless these soil acids, or the major portion of them, have the same chemical composition. Provided soil acids of soils formed under different climatic and geologic conditions are not the same chemical compounds, variations from base-acid ratios and pH from those given here, are to be expected.

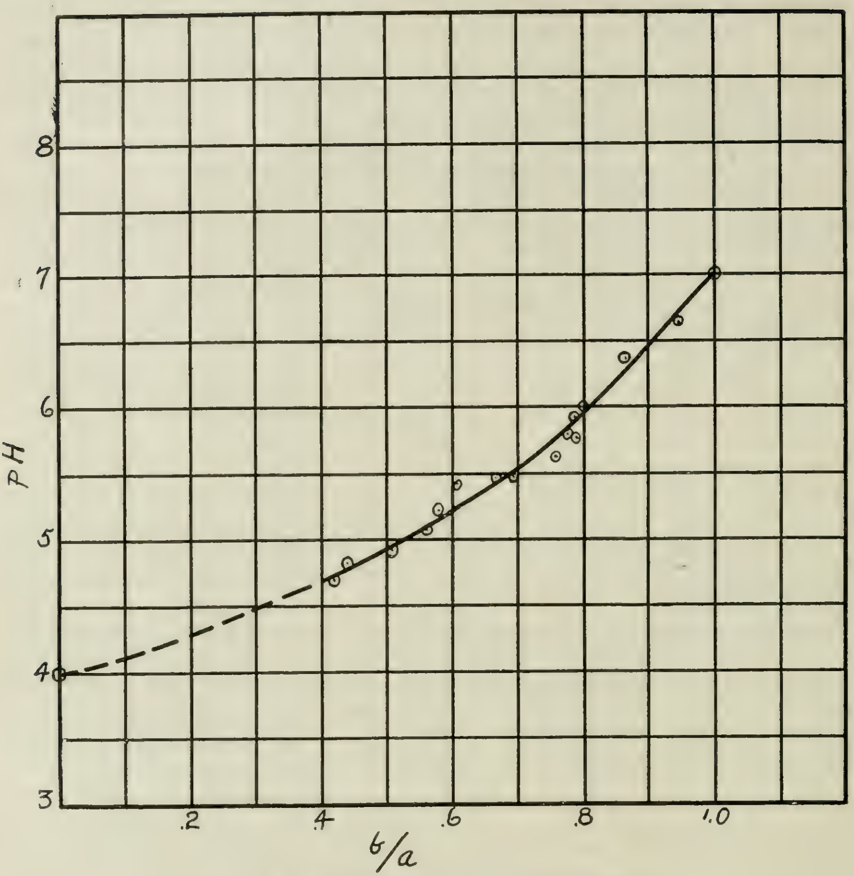


Fig. 11.—Base-acid ratio and pH relationship.

GENERAL DISCUSSION

The causes of the reaction of soils must be considered fundamentally the same as for other chemical agents, and that soil acidity is due to an excess of hydrogen ions and soil alkalinity to an excess of hydroxyl ions. Since mineral soils neutralize both acids and bases the active chemical constituents must be amphoteric in nature. This assertion may also be applied to alkaline soils as data are herein presented showing that the reaction between soil and $Ca(OH)_2$ does not stop when soils are neutralized with this reagent. Evidently alkaline soils contain salts or acids with replaceable hydrogen in their structure or produce hydrogen ions through their dissociation with water. The specific nature of active mineral soil compounds is believed to be largely alkali soil bases combined with complex silicic acids forming amphoteric salts, together with free complex silicic acids. In this work only major reactions or resultant effects were studied and hence it was not known if the reactive soil compounds were single salts or a mixture of different salts and acids. There were evidences, however, of the formation of a series of salts in the alkali titrations, analogous to the salt series formed by titrating H_3PO_4, with KOH, although as previously stated, these salts might have belonged to different series. A large portion of the active materials of soils must be considered insoluble in water, but the solubility of these components is sufficient to determine the reaction of a soil by means of its water solution; but the pH of a soil, or degree of acidity or alkalinity, depends on the relative quantities of hydroge nions and hydroxyl ions in solution which is controlled by the proportion of active bases to active acids, and not by the total quantities of these components present.

Calling attention again to Table 3, all the soils with pH above 7.00 contained carbonates, but no relationship was discovered between content of bases and pH in the four soils studied. Evidently concentration of hydroxyl ions in these soils depends on factors other than soil class and quantity of carbonates. In this connection, it is believed that CO_2 plays an important role. These pH determinations were made on air dry soils and a longer time was required for equilibrium than in case of the acid soils.

The pH of acid soils was found to increase in magnitude on standing in contact with water. These results show that when the pH of field soils is desired it is imperative that the determinations be made on fresh, moist field samples. Results in Table 3 also show that acid soils may have a greater neutralizing value for acids than carbonate soils; and that the major cause for soils becoming acid is the loss of soil bases. While the presence of carbonates may not be necessary for a neutral or alkaline soil, they maintain a balance between silicate-bases and acids when finely divided and well distributed through the soil mass.

The reason for using Al_2Cl_6 in this investigation was that it was assumed that this reagent would hold back the dissociation of soil iron and aluminum and react only with the alkali bases. That this effect might be accomplished was shown by the fact that only slight traces of iron was found in soil solutions after treatment with Al_2Cl_6, by qualitative tests, but because the hydroxide formed coated carbonate and soil particles and tended to prevent further reaction, its use was abandoned. As shown by the results, however, the effects produced by added hydrogen ions in HCl were similar to those obtained by using Al_2Cl_6. There is a point here seemingly of practical importance, that is, injury may result to plant growth if soils are treated in such a manner as to precipitate hydroxides of iron or aluminum in them.

The end point in the soil—$Ca(OH)_2$ reaction is considered to be slightly above pH 7.00. This being the case it may be expected that the end point in a reaction between soils and stronger alkalis will be still higher on the pH scale. Since Hoagland (4) has shown that hydroxyl ion concentrations greater than pH 8.25 were distinctly injurious to barley seedlings, and that hydroxyl ions were more toxic than hydrogen ions for equal divergences from pH 7.00, alkalis might be injurious when added to soils under conditions where the pH would be raised above 8.25. The injurious effects of watering green house plants with large quantities of hard waters are quite well known and may possibly be explained on this basis.

Apparently, the point to be reached in liming soils and proper amounts of liming materials to apply is still an open question. Should soils be neutralized, made alkaline or held at a certain pH? Whatever the answer to this question is, it is evident that more intensive research should be carried on to determine more of the effects of liming soils; the chemical systems set up and their effect on plant growth. The effect of an excess of liming materials applied to soils may be important from a practical standpoint. Evidence was given to the effect that in the presence of an excess of $Ca(OH)_2$ there was a continuous reaction between soils and this reagent. Provided this reaction is between $Ca(OH)_2$ and the more insoluble soil acids a greater quantity of more active acids may be formed in soils than previously existed there, when the added base is again lost from the soils. This situation brings up a question as to the advisability of adding smaller amounts of liming materials to soils often, rather than a large excess at any one time; or the advisability of maintaining the pH at or somewhat below, the neutral point rather than making soils strongly alkaline. The possibilities of crop injury due to the effects of liberating quantities of CO_2 in soils from the use of $CaCO_3$ alone and with acid fertilizers should not be overlooked.

The proper use of various fertilizing materials on different soils containing varying amounts of active materials involves a better understanding of the effects produced by fertilizer treatments. There is need for a clearer definition of the chemical reactions involved. Changing the solubility of soil bases, and varying the pH of soils, as well as the formation of new compounds, undoubtedly exert a great influence on plant growth.

It seems reasonable to assume that the active soil materials are those most concerned with crop production and fertilizer reactions. If the degree of acidity of a soil correlates with crop response then the proportion of active soil bases to acids assumes great importance. The magnitudes of fixation of cations of neutral salts correlates with the quantity of active bases in soils, and the fixation of phosphorus depends to some extent on these substances. Increasing the basic content of soils accentuates these conditions. These factors, then, play an important part in the solubility and retention of fertilizers and the chemical compounds formed by fertilizer salts, in addition to their effects on the soil reaction.

The results presented in this publication give a better understanding of the nature and relationships of soil components, and seem to emphasize the importance of the base-acid ratio in soils. Correlations of great practical value should be obtained from applications of these methods to practical field problems. It is the plan to continue this work along similar lines in an attempt to define fertilizer salt reactions on different soils using data herein contained as a basis for operations.

SUMMARY

The object of this research was to determine the neutralizing value of mineral soils for acids and alkalis by means of the hydrogen electrode and indirect titration. Some of the conclusions drawn are listed below.

1. The neutralizing value of mineral soils for acids and alkalis may be quite accurately determined and methods are devised for this purpose.

2. When soils are treated with $Ca(OH)_2$ the reaction proceeds slowly and comes to an equilibrium on pH 7.00 with the quantity of $Ca(OH)_2$ required to raise the pH of soils to this point in at least 24 hours but in presence of an excess of $Ca(OH)_2$ an equilibrium is not obtained, indicating that this further reaction is continuous over a long period of time.

3. At least one end point in the soil—$Ca(OH)_2$ reaction appears to be slightly above pH 7.00.

4. $Ca(OH)_2$ forms salts with soil acids.

5. A soil-acid equilibrium may be obtained in a short period of time in presence of an excess of acid and this equilibrium is quite constant over a period of several days, showing that a rather sharp distinction may be made between reactive and inactive soil bases.

6. Weak soil acids are split off when soils are treated with strong acids.

7. When the methods devised for determining active bases and excess acids in soils were applied to a series of soils of varying pH, no direct relationships were discovered between soil class, active bases, excess acids and pH; however, a direct relationship was exposed between the base-acid ratio and pH of the soils.

8. The pH and base-acid ratio plotted as a curve corresponds to the normal hydrogen ion concentration curve obtained in weak acid-alkali titrations.

9. The quantities of lime required to neutralize a series of miscellaneous soils do not correlate with their degree of acidity.

10. The base-acid ratio in soils is believed to be of great practical importance.

REFERENCES CITED

(1) Clark, W. Mansfield. 1921. The determination of hydrogen ions. Williams and Wilkins Co., Baltimore.

(2) Gillespie, L. J. and Hurst, L. A. 1917. Hydrogen-ion concentration measurements of soils of two types; Caribou loam and Washburn loam. In Soil Science, V. 4, p. 313.

(3) Hildeband, Joel H. 1913. Some applications of the hydrogen electrode in analysis, reasearch and teaching. In Jour. Amer. Chem. Soc. V. 35, No. 7, p. 847.

(4) Hoagland, D. R. 1917. The effect of hydrogen and hydroxyl ion

concentration on the growth of barley seedlings. In Soil Science V. 3, p. 547.

(5) Knight, H. G. 1920. Acidity and acidimetry of soils II. Investigation of acid soils by means of the hydrogen electrode. In Jour. Ind. Eng. Chem. V. 12, p. 457.

(6) Schmidt, Carl L. A. and Hoagland, D. R. 1919. Table of pH, H and OH values corresponding to electromotive forces determined in hydrogen electrode measurements, with a bibliography. University of California, Publications in Physiology. V. 5, No. 4, p. 23.

(7) Sharp, L. T. and Hoagland, D. R. 1916. Acidity and Adsorption in soils as measured by the hydrogen electrode. In Jour. Agr. Res., V. 7, p. 123.

(8) Spurway, C. H. 1921. Studies on the reactions between soils and various chemical compounds. Mich. Agr. Expt. Sta. Tech. Bul. No. 51.

(9) Spurway, C. H. 1917. Soil acidity and the hydrolytic ratio in soils. In Jour. Agr. Res., V. 11, No. 12, p. 659.

(10) Swanson, C. O., Latshaw, W. L. and Tague, E. L. 1921. Relation of the calcium content of some Kansas soils to the soil reaction as determined by electrometric titration. In Jour. Agr. Res. V. 20, p. 855.

THE OCCURRENCE OF PROTOZOA IN PLANTS AFFECTED WITH MOSAIC AND RELATED DISEASES*

Technical Bulletin No. 58

RAY NELSON

GENERAL CONSIDERATIONS

The mosaic diseases of plants have occupied a prominent place in the field of phytopathological research for many years. Their increasing economic importance and wide distribution have attracted the attention of more and more workers in this country and abroad, and today they constitute a major project for investigation in most of the institutions where botanical research is carried on. For several cultivated crops the mosaic diseases of the infectious type are the most serious diseases known. Much progress has been made along the lines of inter-relationships, modes of transmission, overwintering, etc., but, despite the large amount of work done, the etiology of not one of the group has advanced much beyond the realm of speculation. The enzyme theory has its followers, and there are those who lean toward a belief in the bacterial nature of the causal agents, but apparently the concensus of opinion among plant pathologists is, that the mosaic diseases are analogous to certain animal disorders caused by the so-called filterable viruses. Probably no single factor has so retarded research into the nature of the etiological factor of these diseases as the general belief that the organisms are so small that they can pass through filters, the diameter of whose pores is smaller than the visual magnifying powers of the microscope. While the trend of evidence has seemed to indicate that the particles of infectious material in the form that they are extracted from the tissues of diseased plants are very small, there is little justification for the conclusion that these filterable forms represent the only ones capable of producing the disease. The extreme polymorphism that is characteristic of the life-cycles of many of the protozoa and our lack of knowledge concerning filtration through pressure and suction filters, open for the investigator in mosaic diseases fields for research which have as yet been unexplored.

Recently interest has been aroused through the work of Matz (1)†, Kunkel (2), and Palm (3), who respectively, have found foreign bodies in the cells of sugar cane, corn, and tobacco plants affected with mosaic. Although no definite organisms have been demonstrated in the tissues of any plant affected with mosaic or the closely related diseases, the work in progress indicates a general belief by many workers in the occurrence of such a factor.

---

*The writer is greatly indebted to Dr. G. H. Coons for very valuable suggestions given during the course of this investigation. He also acknowledges the helpful criticism of Dr. E. A. Bessey and his aid in the interpretation of the slides.

†The number in parenthesis refers to the number of the article in the bibliography on page—of this bulletin.

Symptoms of Diseases of This Type

Many of the economically more important plant families contain individuals or groups of plants known to be affected with mosaic disease. More than twenty families have been so recorded. The symptomatology is strikingly similar for nearly all these plants, suggesting a close relationship among the causal agents. With but slight modification or amplification the description of mosaic symptoms on any plant can be made applicable to any other plant of a different group. (See Fig. 1, Bean Mosaic.) In general, typical symptoms include: mottling of the foliage in darker and lighter areas, crinkling of the leaves, or other distortional modifications, dwarfing, reduction in

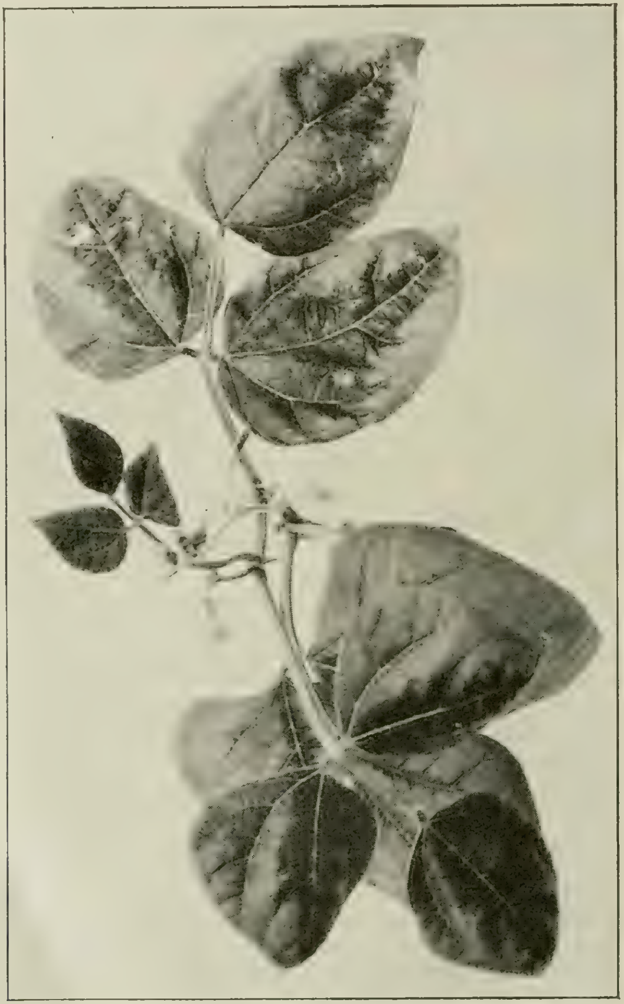


FIG. 1. Bean plant affected with mosaic, showing the typical mottling and distortion of foliage. Slightly reduced.

yield, and communicability of the etiological factor by contact or through the intervention of insects, mainly the Aphididae. Wilting, chlorosis, leaf drop, canker formation, are symptoms specific for certain mosaic diseases but are not generally applicable to the group.

Histological Lesions in Related Diseases

Quanjer (4) has found and described a definite necrosis of the phloem tissues in potato plants affected with leaf-roll. His findings have been confirmed by Artschwager (5). No investigation of the phloem tissues of mosaic plants has so far been reported, and apparently the significance of the association of necrotic tissues in a disease so closely related to mosaic as leaf roll has not been appreciated. In disease phenomena, cause and effect are usually closely associated, so that it seems reasonable to assume that the finding of certain areas specifically affected by disease indicates also the location of the inciting cause. The location in the phloem of the agents which cause the mosaic diseases is further indicated by observations on mode of transmission.

Modes of Transmission

The mosaic diseases, and others, like potato leaf-roll, are transmissible by insects. Plant lice are mainly responsible for the widespread dissemination of the infectious material. The feeding habits of these insects offer valuable evidence as to the probable nature and location of the causal organisms. Those species known to transmit these diseases take their food material from the phloem tissues of the host plants, and after feeding for some time upon the veins and parts of the plants close to the phloem they are capable of transmitting the disease to healthy plants. Other species which do not attack the food-conducting tissues have not been shown consistently to be carriers of the infectious agents.

The fact that some of the mosaic diseases are contagious indicates that the causative agents are generally distributed in the plant. Juice expressed from any aerial part of the plant is usually effective in reproducing the disease when inoculated under favorable conditions into healthy plants. A cytological study employing modern improved methods, in a search for possible causative organisms in the phloem of diseased plants has not been reported. Investigators have reported meagerly upon observations of tissues in mosaic plants but no exhaustive search has been made of the phloem, apparently the vulnerable point of attack in seeking for the solution of the true nature of the mosaic organisms.

PRESENT INVESTIGATIONS

Bean mosaic investigations have been in progress at the Michigan Agricultural Experiment Station since 1919. Most of the work has been concerned with variety and species susceptibility, and with insect transmission. Some cytological work was done during 1921 but was not pursued to any conclusion. As soon as mosaic material was available in the summer of 1922 an intensive histological study was projected, using all of the common killing and fixing solutions and botanical stains. The main object of the investigation was to determine whether or not any organisms could be demonstrated in the sieve tissues of mosaic plants. As the bean work progressed the scope of the investigations was widened to include tomato mosaic, clover mosaic and potato leaf-roll.

Materials

Bean mosaic material has been available in great quantities from a mosaic seed plot which has been grown each year as part of the field experimental work. This has included most of the common varieties of field and garden beans, as well as Lima, yard long, adsuki, rice, urd, tepary, moth and Windsor beans. All of these species showed distinct mosaic symptoms during the summer of 1922, which was a very favorable season for the development and spread of the disease. For a study of healthy tissues, seed from healthy plants was grown under cheese cloth cages in the greenhouse.

Tomato mosaic was common late in the summer and material was collected from several gardens where practically all of the plants were diseased. Potato leaf-roll was not found in great quantity but sufficient typical material was secured for the purpose of this investigation. Clover mosaic was plentiful and was used as a check upon the results obtained in studying bean mosaic, since it has been shown that the mosaic disease of each can be reciprocally transferred.

Methods

In all of the early work on bean mosaic the ordinary botanical histological methods were followed. Paraffin sections were stained with the stains most used by botanists. Many thousand transverse sections were cut of leaf, stem and petiole material imbedded in paraffin and studied under the high powers of the microscope, but, aside from slight deviations, diseased plants revealed nothing more than healthy ones. It was then decided to try other killing and fixing agents and employ new stains. Various solutions used by protozoologists were modified to adapt them to plant material, and protozoan stains were used for coloring the sections. Small bits of stems, leaves and petioles were taken from near the growing points of the plant and fixed for 12-24 hours in the killing and fixing solutions. The material was then washed for 24 hours in running water, dehydrated and imbedded in paraffin in the usual way. A radical departure in technique, and one which it is believed would have illuminated the mosaic problem long ago if employed, was introduced at this point. Longitudinal sections 10 microns thick were cut from the paraffin material. From the photomicrographic illustrations in works published on mosaic and related diseases it appears that the basis of these studies has been mainly the study of transverse sections. Apparently little work has been done in which longitudinal sections have been stained and critically examined. There are probably various reasons for this. It is very difficult to cut longitudinal sections of stem and petiole material due to the lignification of the xylem elements and the presence of fibrous tissue in the phloem. Much patience and a perfect condition of the sectioning razor are essential to success in securing sections that are not badly mutilated. Since the general assumption has been that the organisms were very small and generally distributed throughout diseased plants, the conclusion that transverse sections should contain them was sound from this standpoint. However, the results of the work presented here show why the cross section method has failed. Transverse sections have proved, in the author's work, to be without value so far as showing the location, position or nature of the organisms.

Longitudinal sections are apparently indispensable and have revealed structures not demonstrable by any other method.

Some erroneous views held by botanists have been dispelled by observations of many thousands of sections of bean, tomato, potato, and other plants. Some botanists have taught that nuclei are not present in the sieve tubes. Nevertheless, they occur regularly in sieve tubes in all stages of development and are easily demonstrated by a study of longitudinal sections. Plastids, which are also supposed to be absent from the sieve tubes, are often found in great numbers. This is especially true of cucurbitaceous material. In mosaic plants the plastids may almost surround the nucleus in cells of the sieve parenchyma and adjoining tissues. Abnormal nuclei are also present throughout the phloem of diseased plants and may easily be mistaken for possible organisms by any one not familiar with the material. Chondriosomes are numerous in the parenchyma cells of some of the plants studied and due to their great resemblance to large bacteria, especially in stages of division, are susceptible to erroneous interpretation.

ORGANISMS IN DISEASED PLANTS

Bean Mosaic

The sieve tubes of bean plants are remarkably free from food particles that take the stains used in this work. This is not true with all plants since sections of mosaic material from plants of other kinds have shown these tubes to be filled with deeply staining granules of appreciable size. Because of the clarity of the phloem tissues when properly destained the bean offers excellent material for a study of this kind.

Longitudinal sections of stems or petioles from mosaic plants, killed and fixed in protozoan killing and fixing solutions[1] and stained with Haidenhain's iron-alum haematoxylin, show the constant occurrence of biflagellate organisms in the sieve and sieve parenchyma cells. They are fixed and stained powerfully by these solutions and by proper destaining all color can be removed from all plant structures except the nucleoli and chromatin and still remain brilliant in the organisms. The organisms are relatively large, some individuals being 18 microns in length, and are easily seen with ordinary high power dry lenses. Including the fully extended flagella some individuals will measure 50 microns. These flagellates are scattered throughout the sieve and adjoining parenchyma cells in the stems and petioles of diseased plants. They could not be found in the tissues of healthy plants, of which many were studied, using the same methods of killing, fixing, dehydrating, sectioning and staining. Fig. 2 is a photomicrograph of a longitudinal section through petiole phloem of a diseased plant and illustrates the distribution of the organisms.

The following are the principal forms that have been observed in sections of diseased tissues: (1) Large, elongated, biflagellate, tapering, or cigar-shaped individuals with the form of the body resembling organisms belonging to the genus Leptomonas, the flagella being attached at opposite poles. This is the most common type. (2) Ovaliform biflagellates of the same type. (3) Deep-staining, slightly elongated bodies, surrounded by a lighter envelope, with flagella running down to the centrally stained portion and projecting from each end of this destained envelope. Individuals of this type may be almost spherical and occur in pairs in the same cell. (4) Very small, elongated flagellates, less than 0.5 micron in diameter and similar to type 1. These are common in sieve and parenchyma cells and probably represent very young forms of type 1. (5) Deeply stained oval bodies with degenerate flagella and occasional remnants of an outer envelope. These may be encysted forms. (6) Small, elongated, non-flagellate bodies which occur in great numbers in the degenerate chloroplasts of the sub-epidermal cells of

---

[1] Various standard solutions containing $Hg\ Cl_2$, were used.

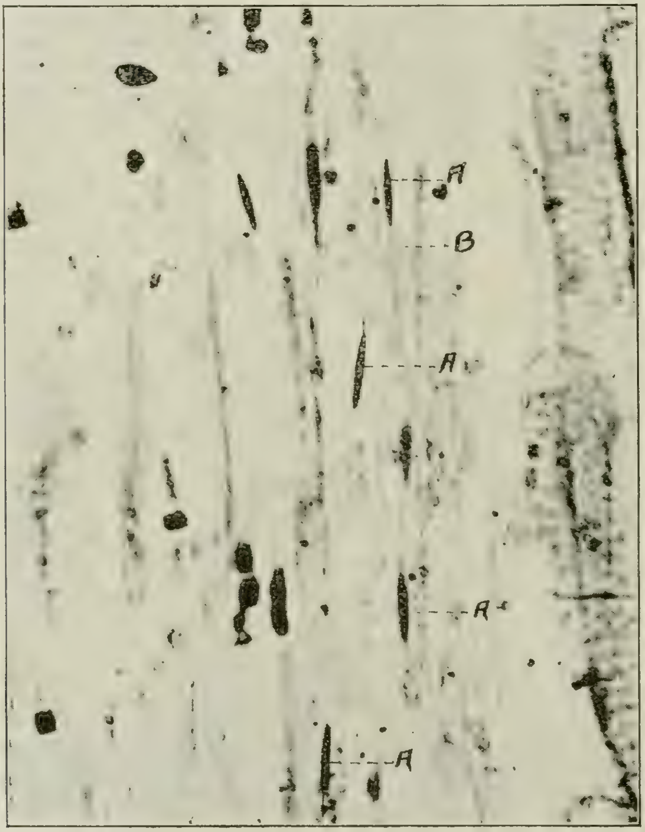


FIG. 2. Longitudinal section through the phloem of bean plant affected with mosaic, showing flagellated organisms lying in the sieve tubes and sieve parenchyma cells. × 650.
A. Body of the flagellates.
B. Flagellum.

diseased stems and petioles. They may entirely fill the cell lumen by their escape from the chloroplasts or remain imprisoned within them (Fig. 7). These organisms are very variable in size but are much smaller than the flagellate forms. Since a detailed study will have to be made of all these types before they can be assigned a place in the life history of this organism they are given only brief mention here, and will be described fully in a future publication. Such diversity of form indicates the probability of extreme polymorphism in the life cycle. Some of these may be transitional forms and others may be merged upon further study.

Types 1 and 2 are shown in Fig. 3, and another individual of type 1 more highly magnified is seen in Fig. 4. The flagella may project in the axial line from the body of the organism or they may emerge slightly to one side of the axial line. The flagella extend into the body of the organism for a very short distance and seem to have their origin in blepharoplasts or basal granules which are located near the extreme ends of the flagellate. These basal granules take the stain more intensely than the rest of the organism and are easily located.

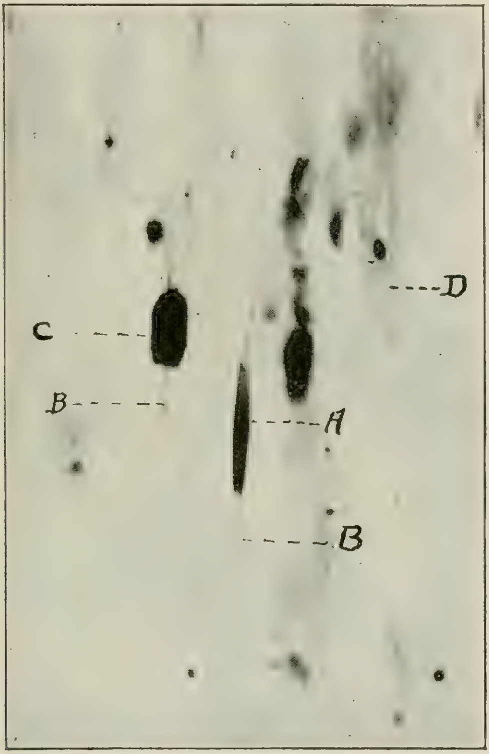


FIG. 3. Photomicrograph of biflagellate, elongated protozoan in sieve tube of mosaic bean plant × 1500.
A. Elongated organism of type 1.
B. Flagellum.
C. Ovaliform flagellate, type 2.
D. Cell nucleus with deeply-stained nucleolus in center.

The nucleus is apparently little affected by the haematoxylin stain, although an occasional one, faintly colored, is seen centrally located in the cell. Special stains will have to be used to bring out details of structure. So far the polychrome methylene-blue stains and their modifications have not given satisfactory results with plant material. The main difficulty seems to be that destaining or dehydration in alcohol removes the stain from the organisms as well as from plant structures.

The majority of these flagellates lie in a plane parallel to the long axis of the host cell. Their length would in most cases prevent their assuming any other position, although smaller forms are sometimes found in an oblique position. The flagella are extended in the majority of cases but may be coiled in various ways. The full extension of the flagella seems to be correlated mostly with the position of the organisms in relation to the host cell nucleus. In nearly every case the flagellates will be found to lie very close to the nucleus with one or both flagella in contact with the nuclear surface, or else the body of the organism is located parallel to the axial line of the nucleus and one flagellum is coiled around it. In one very interesting case the entire body of the flagellate lay in contact with the nucleus, the flagella being fully extended from both poles. Nuclei in various stages of degeneration occur throughout the phloem tissues and there seems little doubt of the direct influence of the presence of the flagellates upon the activities of this structure.

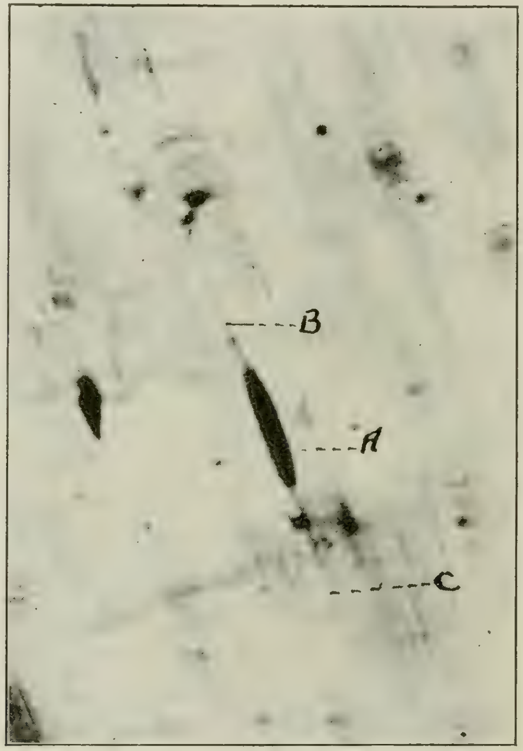


FIG. 4. Photomicrograph of a single biflagellate organism in a sieve parenchyma cell of bean petiole. × 1800.
A. Body of the flagellate.
B. Flagellum.
C. Sieve parenchyma cell.

The mode of division of the biflagellate forms is by simple, longitudinal binary fission. Preceding the division of the organism the basal granules divide, the flagella split throughout their entire length or divide only partially, a v-shape slit appears in each end of the body and division then oc-

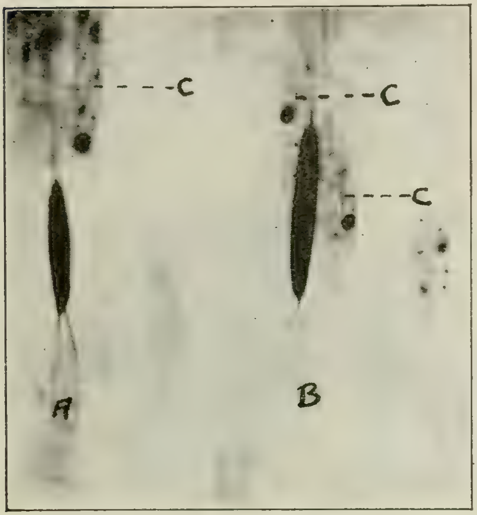


FIG. 5. Photomicrograph of longitudinal section through leaf petiole of mosaic bean plant, showing first stage of division of flagellate and proximity to host cell nucleus. × 1500.
A. Division of flagella preceding longitudinal binary fission into two flagellates.
B. Biflagellate organism lying in contact with host cell nucleus.
C. Nuclei with dark-staining nucleoli in center.

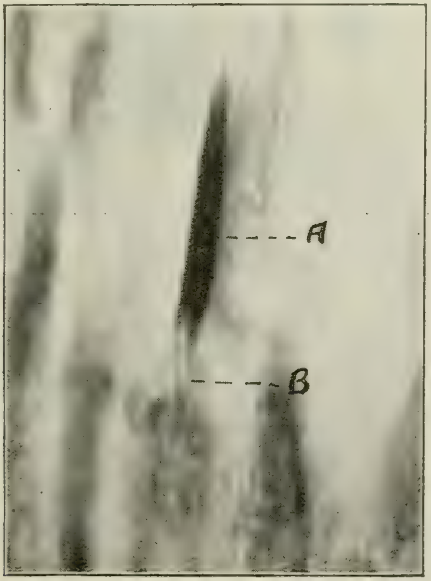


FIG. 6. Flagellate from bean plant dividing by longitudinal binary fission. × 1800.
A. Two daughter flagellates.
B. Flagellum partially divided.

curs, separating the organism into two equal daughter flagellates. These stages of division are shown in Figures 5 and 6. It is very likely that other modes of division occur in the life history of this organism. No form of division which produces the very small flagellates, some less than 0.3 micron in width, has been observed. Whether the large, elongated forms represent the adult type, which would be the basic form for generic classification, or whether some of the other types are the real adults, are questions which can not yet be answered. The form in which the organism is inoculated into healthy plants by the aphids which transmit the disease, and the question of whether or not these insects are merely accidental carriers of infectious material or actual hosts for some form in the life cycle of the flagellates are questions whose answer is merely speculative at present.

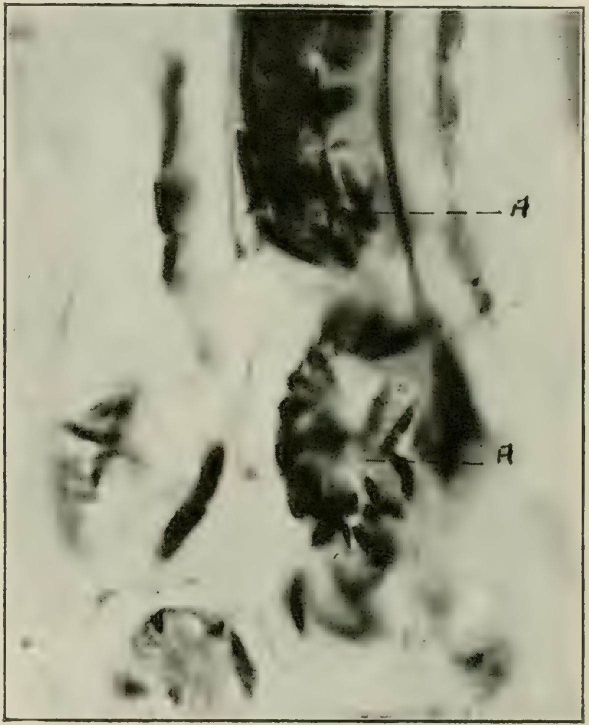


FIG. 7. Photomicrograph of longitudinal section through subepidermal tissue of bean plant affected with mosaic. Note that the chloroplasts are filled with small, elongated, deeply-stained organisms. × 1500.
A. Chloroplasts filled with the organisms.

The migration of these flagellates from cell to cell has not been observed. The small forms might readily pass through the perforations in the sieve plates and thus become distributed throughout the sieve tubes. Likewise the very small flagellates once introduced into the parenchyma cells could possibly pass from cell to cell through the cytoplasmic connections. Further study is necessary for clarification of these points.

The organisms have been demonstrated in living material by means of thin longitudinal sections through the phloem and also by dark field illumination of juice expressed from diseased petioles. The first method is the most satisfactory. Petioles from plants showing severe mosaic symptoms were used and longitudinal sections cut through the phloem after splitting the petiole with a Gillette razor blade. These sections were mounted immediately in boiled water and examined under the high-power dry lenses, the illumination being reduced to a minimum necessary to make out plant structures. The flagellates were seen in the sieve tubes in an actively motile state. In stained as well as living material rarely is more than one individual found in a cell, and some cells contain none, so that it is necessary to find a favorable location on the slide where the flagellates are present. The body of the organism is seen in a rapidly whirling motion, disappearing from sight in the depths of the cells only to reappear again, turning over and over but changing its relative position but slightly in the cell. Only the body of the flagellate can be seen, as the flagella are not visible under these conditions.

For examining the organisms with dark-field condenser short pieces of petiole were laid on clean plate glass and the juice rolled out by means of a photographer's hard-rubber roller. Hanging drops were examined under oil-immersion lenses with arc-light illumination. An occasional flagellate was seen to flash across the field but apparently so few organisms are expressed in the relatively large amount of juice that they are not easily located in this way. Thin longitudinal sections are more satisfactory for observing the motility.

The size of the flagellates is very variable, as would be expected where they are present in various stages of development. Measurements of type 1, the elongated biflagellate forms, which constitute the majority of individuals, are given here. These measurements are based on fixed and stained material and, therefore, will be slightly less than the actual size of the organisms in a living state. A filar micrometer was used in making the measurements and the size of the body determined separately from the flagella. The following table shows the variation in 50 individuals measured in consecutive order as they occurred in the sieve cells:

Longest individual	18 × 2.8 microns.
Shortest individual	5 × 0.3 microns.
Broadest individual	13.9 × 3.9 microns.
Slenderest individual	11.3 × 0.3 microns.
Longest flagellum	18 microns.
Shortest flagellum	7.2 microns.
Average length of organism	13.5 microns.

The generic position of these flagellates does not coincide with that of any of the known protozoa. Before fixing their systematic position decision must first be made as to which form represents the adult type. Individuals with a flagellum attached to each end of the body are most common and appear to represent the adult form, and if generic classification is based on their morphology, then it will be necessary to erect a new genus to include them, as they differ from those genera of protozoa at present known which possess a single flagellum attached to each pole. Mention should be made here of the possible relationship but not generic identity of these organisms to those found in the latex of Euphorbiaceous and Asclepiadaceous plants and belonging to the genus Leptomonas (6). The bean organism is distinctly a different type, however, and its exact position will necessitate further study.

Clover Mosaic

In order to determine if organisms similar to those found in bean plants affected with mosaic were also present in clover plants showing mosaic symptoms, stems and petioles from affected plants were fixed and sectioned in the same way as the bean material. Unfortunately several heavy frosts had occurred before this material was collected and it therefore was not so satisfactory as would have been collections made earlier.

Examination of stained sections showed that the same type of flagellates that were present in diseased bean plants were also present in mosaic clover plants. Since it has been demonstrated that clover mosaic may be transmitted to the bean, producing typical bean mosaic, and vice versa, the finding of similar organisms in mosaic clover and mosaic bean strengthens the probability of a causative relation between the bean flagellate and the disease with which it is associated. The organisms in the clover plants were not found in great numbers and the most of them had apparently been destroyed by the freezing temperatures to which the plants had been subjected. Disintegrating forms were quite numerous in the sieve tubes and non-flagellate individuals were found in greater numbers than flagellate forms. Fig. 8 shows, lying in a sieve tube, a single individual of the same form as type 1 of the bean flagellate. The small biflagellate forms and an occasional broad form found in the bean were also present in clover. The organisms were almost invariably located close to the nucleus and often in contact with it.

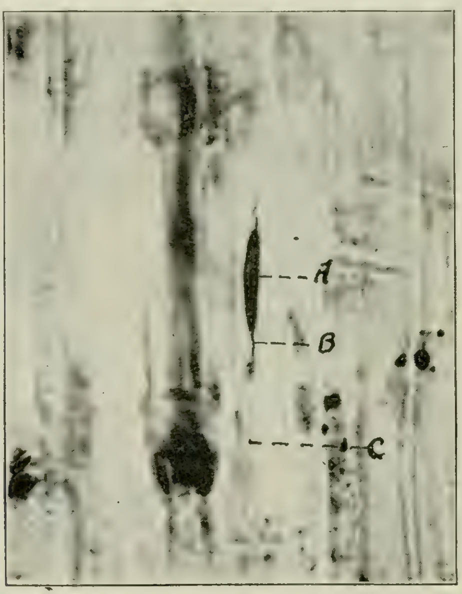


FIG. 8. Photomicrograph of longitudinal section through phloem tissue of clover plant affected with mosaic. A single elongated flagellate is seen lying in a sieve tube. × 1500.
A. Body of the flagellate.
B. Flagellum.
C. Sieve tube.

No extensive study was made of the clover mosaic material, but from the sections examined there seems little doubt of the identity of the flagellates found in diseased plants with those associated with bean mosaic. No measurements were made but in size the clover organisms seem to conform with those measured in the bean.

Tomato Mosaic

No great difficulty was encountered in locating, in the sieve tubes of tomato plants affected with mosaic, organisms which, for this disease, are as constantly associated and as typical as the biflagellates found in bean and clover. In longitudinal sections of stems and petioles, fixed and stained with the solutions used in the study of bean mosaic material, these organisms are found scattered along in the sieve tubes as deep-staining, long, sinuous, tapering bodies, with one or both ends drawn out to a fine point, and usually with one end larger than the other. There is great variation from long and slender to short and relatively broad types, and individuals are present which apparently are in various stages of development. Their location in the sieve tubes is not constant but the majority of them lie in proximity to the host cell nucleus. In all cases, however, the organisms lie in a plane parallel to the longitudinal axis of the cell. For this reason cross sections of tomato are of as little value, so far as finding the organisms is concerned, as are similar sections from the bean, and if by chance a transverse section should sever

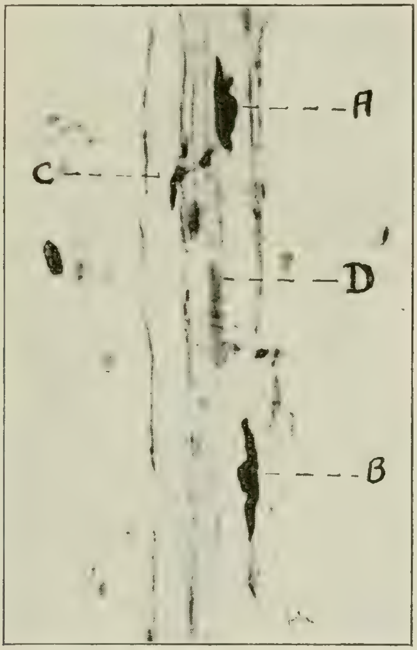


FIG. 9. Longitudinal section through phloem tissue of mosaic tomato plant. × 650.
A. Two trypanosome-like organisms lying side by side in a sieve tube.
B. Two of the organisms attached to each other by posterior ends of the body. This is probably the phenomenon of agglomeration.
C. An organism apparently passing directly through walls of the sieve tube.
D. Sieve tube.

one of them, the nature of the organism would be difficult to determine. The organisms hold quite tenaciously to the haematoxylin stain, and if the sections are mordanted for 6-8 hours in the iron-alum solution, after prolonged destaining they still will be stained deeply while all color will be removed from plant structures except the nucleoli and chromatin. They are not so numerous nor do they occur in an unbroken succession of cells as was often found to be the case with the bean flagellates. They seem rather to occur in "nests," that is, at a certain place in the stem or petiole they will be quite numerous, then for a short distance they will not be found Several individuals may lie in one sieve tube, then for the distance of several cells none will be present. They have been found, however, in all parts of the stem and petiole from which sections have been cut.

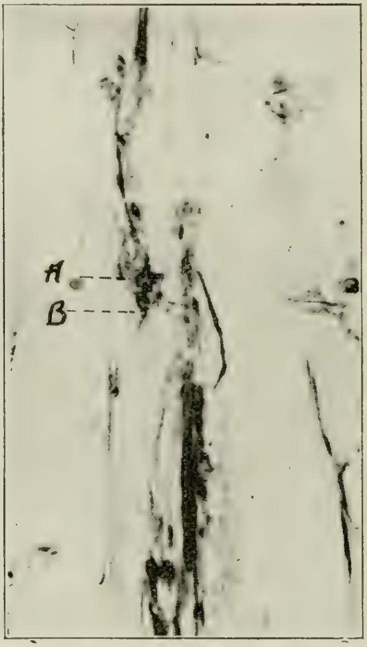


FIG. 10. Photomicrograph of a sieve tube in a mosaic tomato plant showing a small trypanosome passing through a perforation in the sieve plate. × 1500.
A. Sieve plate.
B. Trypanosome.

Fig. 11 shows the typical trypaniform nature of the organisms as they are found in the sieve tubes, while a broader type is seen in Fig. 12. An occasional colony of very small individuals has been seen, the most interesting case being where about eight apparently young individuals were found lying very close to a sieve plate. Division of some larger form or repeated division of the smaller type had apparently produced the increased number. The location of these very small individuals close to the sieve plates is correlated with migration from cell to cell. These small forms have been seen passing through the perforations in the sieve plates. In Fig. 10 is shown one of these small organisms half way through one of these holes in the sieve plate. The only type of division observed was by fission. Longitudinal binary fission

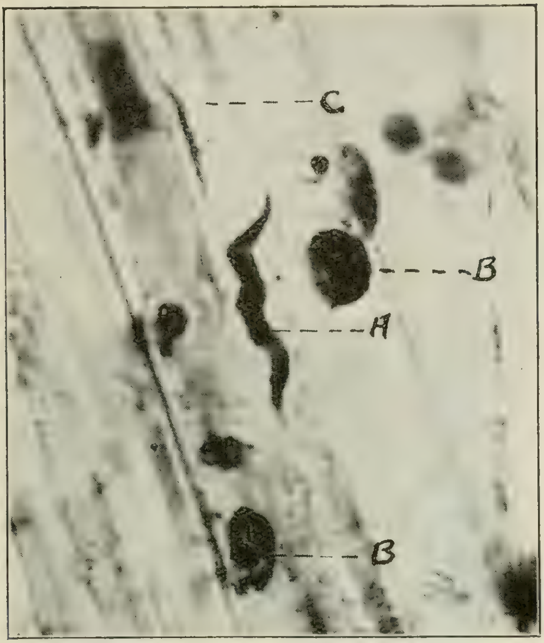


FIG. 11. Longitudinal section of phloem tissue in tomato plant affected with mosaic. A trypanosome is seen in a sieve tube. × 1500.
A. Trypanosome.
B. Cell nucleus.
C. Sieve tube.

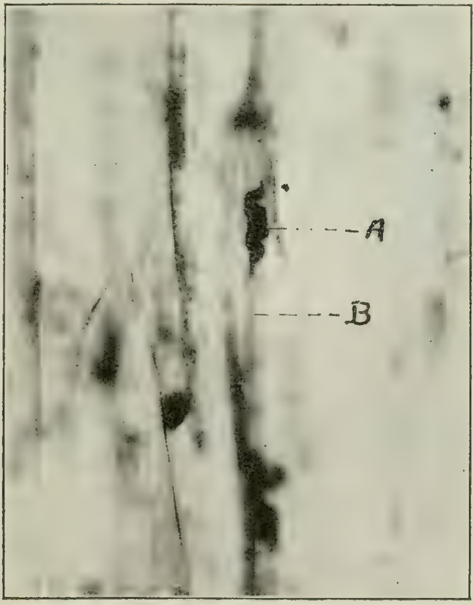


FIG. 12. Photomicrograph of a broad type of organism in a sieve type of a mosaic tomato plant × 650.
A. Trypanosome-like organism.
B. Sieve tube.

was observed in several cases, but only of the small forms. Other types of multiplication probably occur, for undoubtedly the large forms split up into a number of smaller individuals.

The organisms are not invariably of the long sinuous type; many individuals show only a slight undulation of the body and others are almost straight. The slightly sinuous type of organism is shown in Fig. 9, which is a photomicrograph of a longitudinal section through sieve petiole tissue. In this same figure is illustrated what probably is the phenomenon known as agglomeration, that is, two or more organisms attached to each other by the posterior ends of the body. Among protozoa parasitic upon animals especially trypanosomes, agglomeration of individuals is a very common phenomenon. It is supposed to be analogous to agglutinization of bacteria under unfavorable conditions. At first the observation of these organisms in this position is likely to suggest conjugation, but since no definite evidence is available to show that this ever occurs among organisms of this type the rather frequent finding of them in this position is interpreted as representing the occurrence of agglomeration. No explanation is suggested as to its cause, but possibly fixation may be responsible.

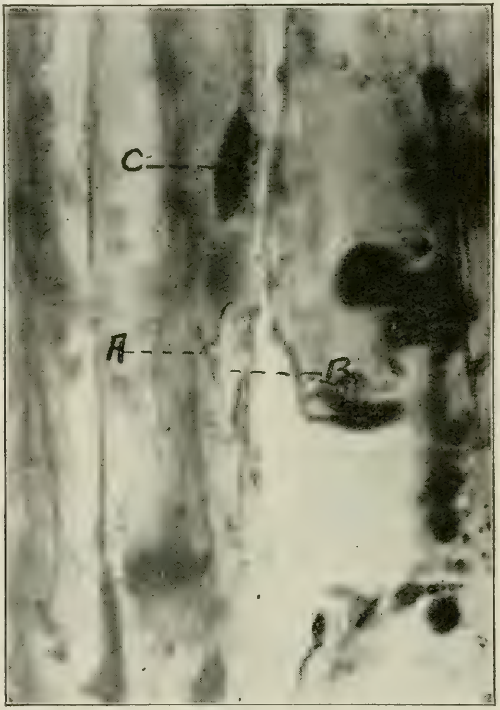


Fig. 13. Photomicrograph of a very small protozoan closely applied to a nucleus, which is destained. × 1500.
A. Protozoan.
B. Destained nucelus.
C. Deeply stained nucleus in adjoining cell.

The size of the organisms varies as widely as do young and old individuals of other protozoa. A very small form is shown in Fig. 13. This is apparently a young organism and it is lying in contact with the host cell nucleus which is destained. Photographed at the same magnification a large individual is shown in Fig. 14. These two organisms illustrate the observed range in size. The figures given in the following table are indicative of the variation found among the organisms but are not to be interpreted as representing conclusive or final sizes of the organisms, for they are not based on measurements of a sufficiently large number of individuals:

Longest individual measured	28.2 microns.
Shortest individual measured	6.2 microns.
Largest individual measured	27 × 6 microns.
Smallest individual measured	6.2 × 0.5 microns.
Average all measurements	15.3 × 2.8 microns.

The total length of these organisms is very difficult to determine because of the sinuous form of the body. The above measurements were made from one extremity of the body to the other of each individual and no attempt was made to ascertain total length. The sizes are, however, comparative for all types.

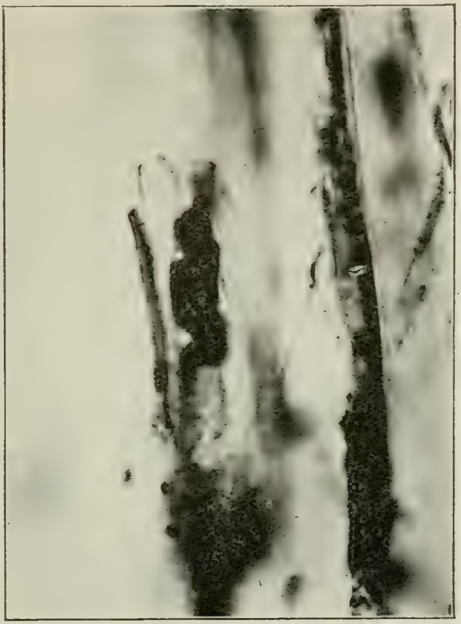


FIG. 14. Very large trypanosome in a sieve tube of mosaic tomato petiole tissue. × 1500. Note comparative size with small form in Fig. 12, same magnification.

The organs of locomotion have not been determined with certainty. An undulating membrane has been seen faintly stained in some of the forms studied, but no definite posterior or anterior flagellum has been demonstrated. The undulating membrane appears to run nearly the entire length of the body and has only been seen on some of the long, sinuous forms. There is such variation shown by the forms found in the sieve tubes—some being very long and sinuous, others almost straight, and still others comparatively short and broad—that the morphology of the species will require extensive investigation. Such polymorphism, however, as was shown by the bean flagellates has not been found in these organisms associated with tomato mosaic.

In the slides stained with haematoxylin only a very few of the organisms have been found with the nucleus sufficiently stained to make it visible. In some of the preparations where destaining was carried far enough it can be made out centrally located in the body, while other deep-staining granules, apparently kinetonuclei, are visible near the extremities. Some portions of the organisms are stained more deeply than others but for a detailed study of structure it will be necessary to develop differential stains or modify some of the present protozoan solutions so as to adapt them to plant material. Much more desirable would be the growing of these flagellates in pure culture and staining them in the absence of the host-plant tissues.

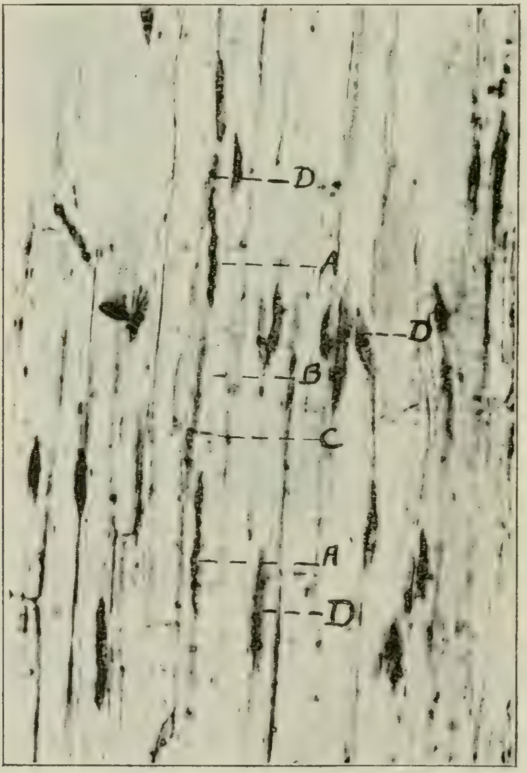


Fig. 15. Longitudinal section through the phloem of a potato plant affected with leaf-roll. Two elongated, slender protozoan organisms are shown in adjoining sieve tubes. × 650.
A. Protozoan organisms.
B. Sieve tube.
C. Sieve plate.
D. Cell nucleus.

Potato Leaf-Roll

The study of material from potato plants affected with leaf-roll has been carried out in the same way as for bean and tomato mosaic. The plants were first carefully examined to exclude if possible any that might also be affected with mosaic. The plants used for this study were taken from a small patch of potatoes where no mosaic was found. They showed unmistakable symptoms of leaf-roll, the lower leaves being uprolled, rigid, brittle, and much thickened, while the entire plant was stunted in growth. Pieces of stem and petiole from near the top of the plant were cut and fixed. Some difficulty was experienced in cutting good sections with phloem and xylem tissue intact.

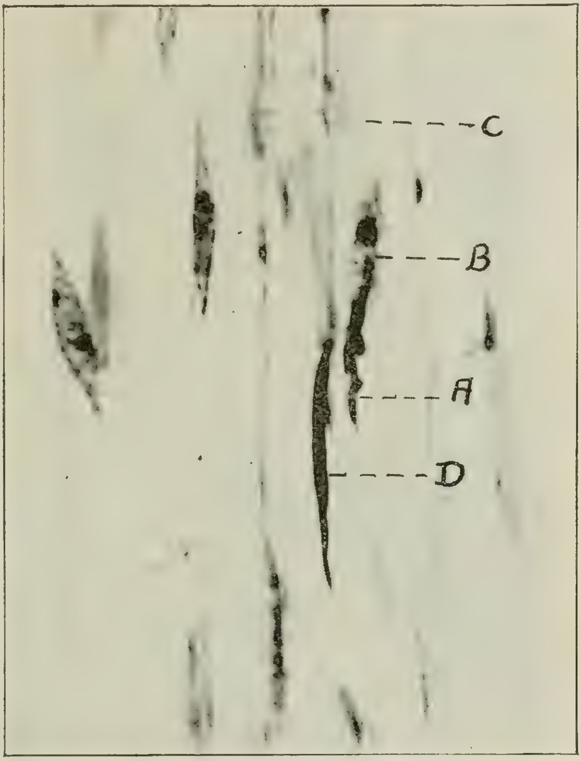


FIG. 16. Photomicrograph of a protozoan coiled around a sieve tube nucleus in a potato plant affected with leaf-roll. × 1500.
A. Trypanosome.
B. Nucleus.
C. Sieve tube.
D. Elongated protozoan partially out of focus.

Lying in the sieve tubes of petioles and stems, long, trypanosome-like organisms were found which stained in much the same manner as the bean and tomato organisms. They vary as much as do the types found in tomato mosaic plants, but are, nevertheless, characteristic and constant for this disease. On account of their distribution in the plant and the tendency to distribute themselves along only certain of the sieve tubes they are not always found readily. They may be present in only one or a few sieve tubes in a bundle, so that in examining longitudinal sections it is necessary to locate the region where they are present. Once they are located they can be found in almost an unbroken succession of cells along the stem or petiole. Two adjoining sieve tubes are shown in Fig. 15 with the organisms in each of them. A great many of these flagellates are found in contact with the nucleus, at least part of the body being in contact with the nuclear membrane. Many times they have been observed actually coiled around it. Such a position of the organism is shown in Fig. 16. This intimate contact with the nucleus is more pronounced and more common than has been observed with the organisms found in tomato and bean mosaic. Many of them, however, are free within the host cell and are found at various places in the cell. Their position is nearly always parallel with the long axis of the cell, although smaller forms are occasionally seen lying obliquely. A large organism is

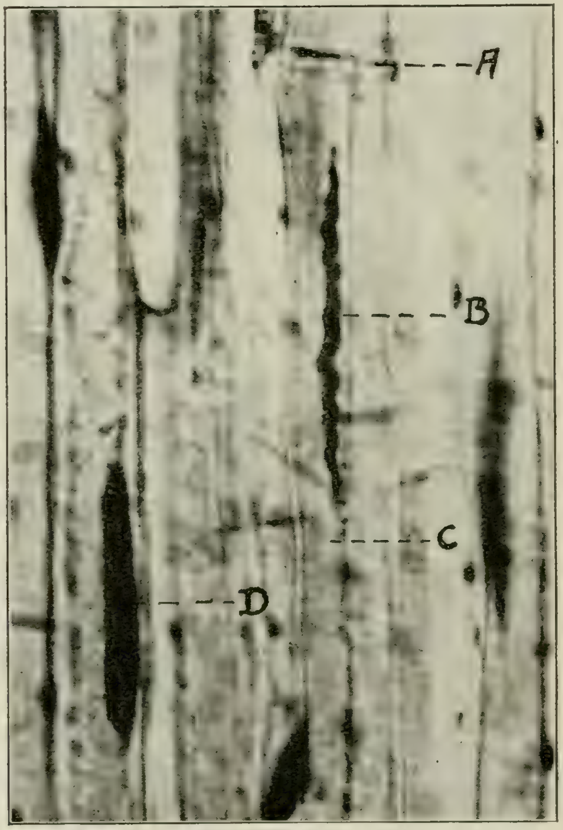


Fig. 17. Photomicrograph of longitudinal section through potato petiole tissue from leaf-roll plant, showing characteristic trypanosome-like organism that is associated with this disease lying in a sieve tube. × 1500.
A. Sieve plate.
B. Trypanosome.
C. Sieve tube.
D. Cell nucleus.

shown in Fig. 17, while a shorter, broader and more sinuous form is seen in Fig. 18. Some of the forms observed are very long and narrow, being less than 1 micron in width. These very slender forms can undoubtedly pass through the sieve plate perforations, although none have been seen in this position.

These organisms appear to possess a distinct undulating membrane, and occasionally an individual has been seen with one end of the body drawn out into a rather long flagellum. The membrane is not clearly visible the entire length of the body so that the point of attachment has not yet been observed. Dark staining granules, very distinct, are located at each end of the body. They are probably blepharoplasts and it seems probable that an undulating membrane runs the entire length of the organism. However, since imagination may easily outrun perception in matters of detail, structural characters will require further study. Extreme cases of body sinuosity are common among these organisms and it is in these individuals that an undulating membrane is most often seen. Some details observed in slides studied include: deep-staining granules in various parts of the organisms; the presence of vacuoles; variation in intensity of staining of various parts of the body, in some cases giving a banded appearance to the flagellate. This is seen in Fig. 16. A centrally located nucleus has not been constantly found in the flagellates examined. For a study of nuclear details other stains will have to be used.

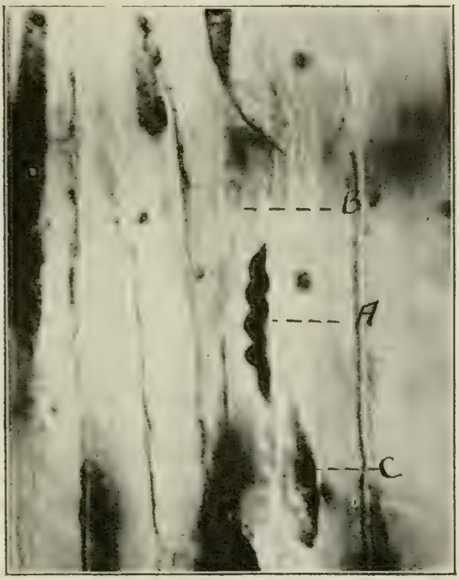


FIG. 18. Photomicrograph of a shorter type of trypanosome found in sieve tubes of leaf-roll potato plants. Note that there appears to be a membrane visible on the right side of the body × 1500.

A. Trypanosome.
B. Sieve tube.
C. Sieve tube nucleus.

The size of these organisms is very variable. The measurements given in the table below show the limits of variation that have been observed:

Longest form measured	35 microns
Shortest form measured	11.3 microns
Broadest form measured	3.0 microns
Slenderest form measured	0.9 micron
Average all measurements	23.6 × 1.8 microns

Smaller individuals than those given in the table above have been seen, but on account of their position in the cell have not been measured. Some are coiled around the nucleus, others occupy positions such that a portion of the body is obscured, so that the measurements given in the table, while representative of a majority of individuals, can not be said to show the extreme variation in size. Further study and measurements of a large number of individuals must be made before any definite conclusions concerning these points can be made.

For a study of healthy tissues sections were made from plants that showed no symptoms of leaf-roll. No organisms have been found in the sieve tubes of these plants in all the slides examined. From all the evidence gathered in this study of diseased and healthy material it seem safe to conclude that these organisms occur in the sieve tubes of diseased plants but are absent from these structures in healthy ones.

Nature of the Organisms

From the study that has been made of the organisms associated with the diseases investigated there seems little doubt of their protozoan nature. Their simple unicellular structure, possession of flagella and undulating membranes, the presence of kinetonuclei and other characteristics that coincide with the peculiarities of the protozoa, seems sufficient proof of the true nature of the forms found in the phloem tissues of plants affected with mosaic and similar diseases. The systematic position of these organisms is a question requiring more detailed study. While not final, the evidence now seems to warrant a few conclusions, which may be considered tentative until further study shall place these forms in their proper generic position. The biflagellates associated with bean and clover mosaic are apparently a new form, since no type of protozoan similar to it has been described. It differs from other probably closely related types, like Leptomonas, in the arrangement of the flagella. The Leptomonas organisms found in the latex of Euphorbiaceous and Asclepiadaceous plants are typical members of that genus with a single polar flagellum, while the bean organism has one flagellum attached to each pole, a characteristic that is constant in all the material examined.

The great resemblance of the organisms found in mosaic tomato plants to trypanosomes is unmistakable. While there is great variation in the morphology of various individuals the general characteristics are more nearly like those of trypanosomes than any other form. The great polymorphism shown by the different species included within the broad limits of the genus Trypanosoma admits forms which might possibly belong in other subdivisions that have been proposed for this genus. They have, however, not been generally accepted by protozoologists. Certain details of structure have not been demonstrated with the stains that have been used, so that for the present the systematic position of the tomato organism must be left open for further study.

The potato leaf-roll organism is a protozoan which even more strongly resembles members of the genus Trypanosoma. The sinuous form of the body and the occurrence of an undulating membrane are characters which belong only to organisms of this type. That other forms also occur in the life cycle is very probable. Some of the long slender organisms found in the sieve tubes have a great resemblance to spirochaetes. They are, however, much larger than any known species, and slender trypanosomes have often been mistaken for spirochaetes by protozoologists. The recent work of Mesnil with *Leptomonas Davidi,* a parasite in the latex of Euphorbiaceous plants, has shown that these organisms exhibit great polymorphism, some individuals being typical Leptomonads, while others more nearly resemble trypanosomes. It is probable, therefore, that the potato leaf-roll organism will be found to contain quite widely varying forms in its life-cycle.

OTHER KNOWN PROTOZOAN DISEASES OF PLANTS

Lafont (6), Franca (7), Mesnil (8), Franchini (9), and other European workers have found protozoa in plants belonging to Euphorbiaceae, Asclepiadaceae and Urticaceae. Typical Leptomonad forms have been found in the latex of Euphorbiaceous plants, and these organisms are constantly associated with a disease of the plants, characterized by etiolation and wilting. Transmission of the flagellates has been shown to occur through the agency of sucking insects (Coreidae). In the bodies of these insects the protozoan passes a portion of its life-cycle, eventually developing non-flagellate forms which are found in the salivary glands. Flagellate Leptomonad and Tryptomonad forms have been found in the latex of *Ficus parietalis*, as have also some characteristic amoeboid organisms.

The measurements of the flagellates from the latex of the Euphorbiaceous plants very nearly coincide with those found in bean plants affected with mosaic. The mono-flagellate character of the organisms from the latex of these plants indicates that these are distinct from the organisms associated with bean and clover mosaic.

The demonstration of protozoa as the cause of plant disease had its inception in 1910 in the work of Lafont (6) who found the Leptomonad forms in the latex of certain Euphorbiaceous plants. This stands as the first record of a plant disease caused by a protozoan parasite. That a great many other plant diseases of unknown cause, will, upon investigation, yield similar results, is not unlikely from the evidence now available of the relation of these simple organisms to plant disease.

PROBABLE RELATION OF THE ORGANISMS TO THE DISEASES WITH WHICH THEY ARE ASSOCIATED

Since the description of tobacco mosaic by Mayer (15) in 1886, the cause of this and other mosaic diseases has been a question of paramount interest to phytopathologists. There is no longer any doubt of the infectiousness of material from diseased plants, and that the power of such a small amount of material to produce disease when introduced into healthy plants is a characteristic of some "living contagium" seems evident from the work of Allard (14) and others. The fact that insects carry and transmit the causative agents of these diseases is itself significant, because of the known facts of insect transmission of protozoan animal and human diseases. Further, the paucity of definite experimental proof of the absence of visible organisms in plant tissues affected with mosaic, is evident from an examination of the literature. Finally, the apparent ultra-microscopic size of infectious particles which pass through the bacterial filters seems to have been the barrier which has hitherto deterred extensive attempts by cytological methods to demonstrate visible organisms in constant association with mosaic plants.

In this investigation the finding of definite protozoan organisms in constant association with mosaic plants and their absence from healthy ones indicate that they are probably the factor so long sought as the cause of these diseases. The fact that the mosaic diseases are cross-inoculable among groups of closely related plants, and the finding of similar organisms in mosaic bean and clover plants makes this seem even more probable.

The work of Elmer (10), who claims to have obtained successful results in cross-inoculation studies of mosaic from Cucurbitaceae, Solanaceae, and Leguminosae, will need extensive confirmation under carefully controlled conditions, especially since other investigators have reported negative results from similar attempts, and also because of the diversity of form shown by the flagellates from diseased plants in these different families. The possibility of great polymorphism within the same species, and the adaptation of organisms to changed conditions must, however, also be kept in mind. Until these organisms can be isolated and grown in pure culture and inoculated into healthy plants, the evidence of their causal relation to the diseases in question necessarily will be circumstantial. Such studies are now in progress and also cytological work in an attempt to find in the aphids which transmit the causative agents, forms belonging in the life-cycle of these flagellates. Success in this last venture would greatly strengthen the evidence now available.

Concerning the filterable nature of the infectious agents of mosaic diseases, investigation is much needed of the process by which colloidal and other particles pass through the pores of these bacterial filters. Some of the very slender forms of the bean flagellates, less than 0.3 micron in diameter, might pass through the medium filters. There is also the possibility of "symplastic" forms somewhere in the life-cycle. In this connection Schaudinn (11) has expressed the opinion that some stages of trypanosomes investigated by him were small enough to pass through bacterial filters. Moore and Breinl (12) have asserted that infected blood retained its infectiousness after filtration. The work of Fry (13) with *Trypanosoma brucei* is in line with these observations. He states that *T. brucei* can throw off particles which, when liberated in the blood, have a motility of their own. This extrusion of granules he regards as of a vital and not degenerative nature. The filterable nature of certain spirochaetes which, in size, are comparable to the small flagellates present in bean mosaic, and the possibility, as expressed by some bacteriologists, that the organisms which are said to *pass* through bacterial filters, actually *grow* through the pores, disclose a field for investigation, which undoubtedly will yield important results.

SUMMARY

Using modern cytological methods, protozoan killing and fixing solutions and protozoan stains, an intensive study has been made of bean mosaic, clover mosaic, tomato mosaic and potato leaf-roll. Definite protozoan

organisms, located mainly in the sieve tubes and sieve parenchyma, have been demonstrated to be constantly associated with these diseases.

The bean and clover organism is a biflagellate, elongated protozoan whose generic position is near Leptomonas. It apparently is a flagellate of new generic rank, since the location and attachment of the flagella differ from the structure in any known genus.

The organisms found in mosaic tomato plants apparently are trypanosomes, or are closely related to this genus. They have been found only in the sieve tubes. Their size varies from 6 to 30 microns in length and from 0.5 to 6 microns in width.

In the sieve tubes of potato leaf-roll plants, organisms have been found which more closely resemble trypanosomes than any other form. They are usually closely associated with the host cell nucleus. These organisms are also variable in size, some individuals being less than 1 micron wide and 12 long, while the longest one measured was 35 microns.

All of these organisms lie in a plane parallel to the long axis of the cell and have been demonstrated only in longitudinal sections.

LITERATURE CITED

(1) Matz, J.
1919. Infection and Nature of the Yellow Stripe Disease of Sugar Cane. (Mosaic, Mottling, etc.) Jour. Dept. Agr. Porto Rico **3**: 65-82.

(2) Kunkel, L. O.
1921. A Possible Causative Agent for the Mosaic Disease of Corn. Bull. Exp. Sta. Hawaiian Sugar Planters' Assoc. Bot. Ser. 3, No. 1: 1–14, *pl. 1–15.*

(3) Palm, B. T.
1922. Is the Mosaic Disease of Tobacco a Chlamydozoonose? (Preliminary note.) Bull. van het Deli Proefstation te Medan-Sumatra, No. 15. (Translated by P. G. Wilson.)

(4) Quanjer, H. M.
1913. Die Nekrose des Phlöems der Kartoffelpflanze, die Ursache der Blattrollkrankheit. Meded. Rijks Hoogere Land-, Tuin-en Boschbouwschool. Wageningen, deel 6, afd. 2: 41-80, *pl. 2–9.*

(5) Artschwager, Ernst F.
1918. Histological Studies on Potato Leafroll. Journ. Agr. Res. **15**: 559-570. *pl. C. and 35-45.*

(6) Lafont, A.
1910. Sur la présence d'un Leptomonas, parasite de la classe des Flagellés, dans le latex de trois Euphorbiacées. Ann. de l'Institut Pasteur **24**: 205-219, *fig. 1-7.*

(7) Franca, Carlos.
1920. La Flagellose des Euphorbes. Ann. de l'Institut Pasteur **34**: 432-465, *pl. 1-2.*

(8) Mesnil, Felix.
1921. La "Flagellose" ou "Leptomoniase" des Euphorbes et des Asclépiadacées. Ann. Sci. Nat. **3**: 42-57, *fig. 1-4.*

(9) Franchini, G.
1922. Flagellés et amibes d'une Urticacée exotique, Ficus parietalis. Bull. Soc. Path. Exot. **15**: 399-404, *fig. 1-3.*

(10) Elmer, O. H.
1922. Mosaic Cross-Inoculation and Insect Transmission Studies. Science N. S. **41**: 370-372.

(11) Schaudinn, F.
1904. Generations-und Wirtswechsel bei Trypanosoma und Spirochaete. Arbeiten aus dem Kaiserlichen Gesundheitsamte **20**: 387-439, *fig. 1-20.*

(12) Moore, J. E. S., and Breinl, A.
1907. Cytology of the Trypanosomes. Ann. Trop. Med. and Parasit. **1**: 441-482, *pl. 38-42.*

(13) Fry, W. B.
1911. The Extrusion of Granules by Trypanosomes. Proc. Royal Soc. London (B), **84**: 79-80.

(14) Allard, H. A.
1914. The Mosaic Disease of Tobacco. Bull. U. S. Dept. Agr. 40: 1-33, *pl. 1-7.*

(15) Mayer, Adolf.
1886. Ueber die Mosaikkrankheit des Tabaks. Die Landwirtschaftlichen Versuchs-Stationen, **38**: 450-467, *pl.* 3.

FOREWORD

The spoilage of foods may be due to physical, chemical or biological causes. The last named is generally known to be the most common and serious cause, and microorganisms are admitted to be the usual biological factors involved. A common type of spoilage in canned foods, called flat sours, results in an increased acidity of the contents of the can with not enough internal pressure to cause bulging of the ends. No extensive bacteriological study of flat sours had been made at the time of undertaking the work reported in this bulletin.

In the course of the studies an extremely interesting and unusual organism was encountered. Part I deals with a description of this organism as reported by Mrs. Wyant, formerly Research Associate in this Section. Part II is the record of an attempt to discover the organism or organisms responsible for flat sours. Mrs. Wyant was assisted in her efforts by two students, Miss Rhea East and Miss Esther Severance. Mr. Tweed, who has succeeded Mrs. Wyant in charge of investigations into food bacteriology was assisted by an advanced student, Miss Lucile Roach. They have made a valuable contribution to the subject.

WARD GILTNER.

FLAT SOURS

PART I

An Interesting Thermophile Encountered in Canned String Beans

Technical Bulletin No. 59

ZAE NORTHRUP WYANT

The organism described in this paper was encountered in all cans examined (quart Mason jars) of one pack of string beans which were under-processed in the hot water bath (2½ hours only) when canned by the cold pack method. At this particular time a study was being made of flat sours. Just previously an effort had been made to obtain from a nearby source canned goods affected in this way in order that more exact information could be obtained with regard to the methods employed in preparing and processing food. The canned string beans studied were home grown and all directions for picking, preparing and processing by the cold pack method were followed with the exception of those for the length of time the cans were to be heated. The cans were stored in a cool place in the basement.

All of the cans of string beans sometime later were observed by the housewife to contain a greater or less amount of white sediment. There was no evidence of a swell or leak. One of the cans was opened and prepared for a meal, but the odor which had seemed normal at first became intensely disagreeable on heating, so that the beans were not eaten. An unopened can of the spoiled beans containing a large amount of white sediment was obtained for bacteriological analysis. Although the cover was not bulged, when opened there was evidence of considerable gas pressure. This effect was probably exaggerated as heat was employed in sterilizing the cover, alcohol being poured over it and burned off. The string beans were decidedly sour, having a pH value of 4.4.

The beans at first had a decidedly putrefactive odor. Some of the liquor when poured out into a beaker had this same odor; on standing, however, the bad odor became less prominent and finally disappeared altogether or became almost supplanted by an odor resembling that of pineapples. Several persons described the odor as being "fruity." Bacteriological studies were made of the liquor and sediment as follows:

Microscopic examination of the sediment showed a large number of bacteria, some having about the same morphology as *B. botulinus*, others were rods smaller and thinner. All proved to be Gram negative. (Gram negative rods, largely, were also found by Barlow in spoiled corn incubated at high temperatures). However, this observation did not eliminate the possibility of the presence of *B. botulinus*.

To determine what different types of bacteria were present, three dilution plates were made in string bean agar plus brom thymol blue, and incubated both aerobically and anaerobically (under sterile paraffin) at 25°, 37° and 55°. Enrichment cultures were also made in sterile pork infusion (meat piece medium) for isolation of *B. botulinus* should it be present. These latter cultures proved negative.

At the same time two guinea pigs weighing about 275 grams each were fed directly by means of a pipette with 0.5 c. c. of the string bean liquor to see if it was toxic.

RESULTS OF EXPERIMENTS

Two types of colonies were found on the aerobic string bean agar plates at 25°. Transfers from each type were made to sterile tubes of string beans and incubated at this temperature both aerobically and under sterile paraffin oil. Visible growth was obtained aerobically but not under oil. This suggested that the types of bacteria isolated were not the cause of the decomposition in the can of the string beans because the organisms in the can were anaerobic or facultative as to their air requirements. This was not considered as conclusive evidence, however. No colonies were found on the aerobic plates at 37° or 55° nor on the anaerobic plates at room temperature and 37°C. At 55°, however, gas bubbles were formed extensively underneath the paraffin which was liquid at this temperature. Eight days after inoculation when the paraffin was removed from the 55° plates no visible colonies could be seen on the first two dilution plates; on the third plate a yellowish mass about 1 mm. in diameter but not resembling a colony was present which on examination under the microscope appeared to contain bacteria, confirmed by a hanging drop.

Shake cultures (designated as Str. BIC) were made from this colony in gelatin agar −1.0 and kept at room temperature; both aerobic and anaerobic shakes were made in corn agar, starch agar, and in string beans, incubating the last named cultures at 55°. In 15 hours gas production was noted in the starch agar shake, but not in the other two media. (See table 1.)

About this time, eight days after the first cultures and feeding experiments were made, one of the guinea pigs died, and all cultures from the contents of the stomach, small and large intestines, and from the heart blood, when grown at 55° in starch agar showed the same gas formation. Two days after this a small loopful of the heart blood drawn aseptically from the other guinea pig was cultured in starch agar at 55° with the same result. The thermophile was thus found to be living and evidently growing in the blood stream of the guinea pig with no apparent harm to the animal. About a month later cultures were made from large quantities of the heart blood of the living guinea pig with negative results. The pig seemed to have survived the temporary bacteremia (?) with no harmful results. Barlow found that no toxic effects on man were apparent after swallowing three teaspoonfuls of corn spoiled by a thermophile and concludes that "apparently its growth at high temperatures in canned corn does not result in the production of toxins." He also states that, "This thermophilic organism does not grow at temperatures as low as the blood temperature of mammals," but cites no experiments to prove this statement.

In the meantime, in spite of the fact that active gas production continued to occur in the starch agar shakes of the organism, Str. BIC, no colonies appeared. Transfers were made from the starch agar shake showing continual active gas formation to a number of different tubes of media both solid and liquid, and incubated under sterile paraffin at 55°C. A considerable number of these media showed growth within 15 to 18 hours as evidenced by vigorous gas production, but even after several days no colonies could be observed even in the clearest media in which gas was formed. The plain agar employed was exceptionally translucent yet no visible growth was evident. The fact remained, however, that growth *was* present or gas would not have continued to form, consequently a very careful examination was made using a hand lens and an artificial light, manipulating the tube this way and that to get the effect of both transmitted and reflected light. The result of this effort was that quite large lenticular colonies could be seen only when the tube was held a certain way between the observer and the light. The "low visibility" of these colonies was due to the fact that they had about the same refractivity as the agar in which they were growing. Having convinced different members of the laboratory staff after much trouble that colonies *were actually present,* these colonies were variously described as appearing like "ghosts" of colonies, like "the place where small gas bubbles had been," or "like pieces of something in the agar." After the observer knew what to look for these colonies were quite easily discernible to the unaided eye. Barlow called the gas bubbles forming in his corn agar shakes "gas colonies" and made his isolations from a well isolated gas bubble. It has been found impossible to make a satisfactory photograph of these colonies, but young cultures show gas formation.

This organism seemed to grow best in a tube shake culture in certain media which favored it when placed under anaerobic conditions.

Visible colony formation has never been observed in anaerobic plate cultures using paraffin, or pyrogallic acid and sodium hydroxide; in fact, anaerobic tube and plate cultures have never shown growth using the latter method, even when the most favorable media have been employed. It is quite evident that an anaerobic condition could never be obtained employing an ordinary aerobe to partially or totally exhaust the oxygen, as with Giltner's H-tube, especially if the culture were placed immediately at 55°. An attempt was made to obtain surface growth by first exhausting the oxygen by placing the H-tube containing the thermophile and *B. subtilis* at the optimum temperature for the latter organism until a maximum growth had been obtained, then placing the culture tube at 55°, but without success. No surface growth, as was determined by direct microscopical examination and by culturing, could be obtained by any of the ordinary anaerobic methods. The possibilities of obtaining surface growth, however, have not been exhausted. In many media in which Str. BIC grew but had not been observed to form gas, growth was not evident for several weeks. Perfectly clear broth was inoculated and covered with sterile paraffin. No gas or clouding was ever evident but after about a month at 55° a moderate amount of whitish, flaky sediment was found which upon examination proved to consist of bacteria and spores. The odor of the cultures in all media which showed gas production, after about a month at 55° was from a rather pleasant fruity odor to one that was more or less disagreeable according to the medium and to the observer; in fact the peculiar odor was practically the only gross test for growth in media in which the organism was multiplying but in which its development was not evident to the eye.

A list of the media follows in which this organism has been cultured. The several media in which growth was evident by gas formation or by odor only, is indicated by a + sign.

Table I.—Record of Growth of Str. BIC on Different Media

Agar.	Inoc.	Growth.			Remarks.
Actinomyces	4/21	+4/22	....	....	
Albumen + BTB	4/21	+4/22	+4/24	....	
Cider	4/21	+?4/22	−4/23	+4/24	
Citrate Glycerin	4/21	−4/22	−4/23	+4/24	
Corn	3/15	−3/16	−4/22	−4/21	No colonies evident.
Corn + C-R	4/21	+++4/22	....	....	
Corn + MR	4/21	+4/22	....	....	
Corn + BTB	4/21	++4/22	+++4/23*	....	
Dextrose blood, heated	4/21	+?4/22	−4/23	+4/24	
Dextrose blood, not heated	4/21	−4/23	....	....	
Dox's	3/15	++3/16	−4/22**	−4/23	
Gelatin agar, −1.0	4/21	+4/22	+8/27	....	White or bluish-white colonies near the surface, Str. BIC?
Glycerin	4/21	?4/22	−4/23	+4/24	
Hydrocellulose	3/15	+?3/16	−4/22	−4/23	
Lactose	4/21	−4/22	−4/23	+4/24	
Liver	3/15	−3/16	−4/22	−4/23	
Litmus dextrose	3/15	−3/16	−4/22	−4/23	4/21 no colonies show.
Mannit	3/15	−3/16	+?4/22	+4/23	8/27 a violet colored growth along stab about 0.5 to 1.0 cm. below the surface and extending 2/3 down the center of tube.
N-free ash	4/21	+?4/22	−4/23	+4/24	
Pea	3/15	+3/16	−4/23**	....	4/21 only one colony evident.
Plain	3/15	++3/16	−4/22**	−4/23	
Potato, no sucrose	4/21	−4/22	−4/24	....	
Sodium asparaginate	3/15	−3/16	−4/22	....	
Soil extract	4/21	+4/22	+8/27	....	
Starch + C-R	3/15	−3/16	−4/22	−4/23	
Starch + BTB	3/15	+3/16	−4/22**	−4/23	+4/24 +8/27 (decolorized).
Starch + BTB in H-tube	4/21	+4/22	+4/23	....	
Starch + MR	4/21	−4/22	+4/24	+8/27	
Tomato	3/15	−3/16	+4/22	....	
Triple sugar −1.5	4/21	+4/22	....	....	

Broth.	Inoc.	Growth.			Remarks.
Acetic acid N/20	4/21	?4/22	−4/23	+4/24	
Acetic acid N/10	4/21	+?4/22	−4/23	+4/24	
Dextrose	4/21	+4/22	+4/23	+4/24	
Litmus lactose	3/15	+?3/16	−4/22	−4/23	4/21 1 cm. gas in tube, decided sediment, broth clear.
Ordinary	3/15	−3/16	−4/22	+4/23	Broth clear, considerable flaky sediment.
Ordinary + BTB	4/21	−4/22	−4/23	+4/24	
Sucrose	4/21	−4/22	....	....	
Tryptophan	4/21	+4/22	+4/23	+4/24	8/27 Very turbid and opaque.

*Decidedly yellow. **This was before colonies were seen.

Table I.—Concluded

Agar.	Inoc.	Growth.			Remarks.
Gelatin.					
Ordinary plus H_2O+	3/15	−3/16	−4/22	−4/23	
3% sucrose	4/21	+?4/22	−4/23	++4/24	
Solutions.					
Cohn's	4/21	+4/22	−4/23	+4/24	8/27 fine crystalline precip.
Hippuric acid	4/21	?4/22	−4/23	+4/24	8/27 glassy-like thin film.
Krainsky's NH_4NO_3	4/21	+?4/22	do. 4/23	+4/24	
Nitrate peptone	4/21	?4/22	do. 4/23	+4/24	
Peptone + Pb acetate	4/21	−4/22	−4/23	+4/24	8/27 flocculent sediment also floating.
Uschinsky's	4/21	−4/22	−4/23	+4/24	8/27 heavy flocculent sediment.
Winogradsky's + N	4/21	....	....	....	
Winogradsky's without N	4/21	?4/22	−4/23	+4/24	
Dunham's	3/15	−3/16	−4/22	+4/23	No sediment 4/21.
Vegetables.					
Asparagus	3/15	+3/16	−4/22	−4/23	4/21 juice clear, sed. from asparagus or culture?
Cider	4/21	++4/22	+4/23	++4/24	
Corn	3/15	+3/16	−4/22	−4/23	
Potato	3/15	+3/16	++4/22	....	4/21 Potato split with gas and apparently somewhat disintegrated.
String bean juice	3/17	?3/18	−4/22	−4/23	
Peas	3/15	+3/16	−4/23	....	4/21 Slight clouding, flaky sed. and flaky particles throughout liquid.
Miscellaneous.					
Blood serum coagulated	4/21	+?4/23	....	....	
Hay infusion	4/21	++4/22	−4/23	+4/24	
Cooked pork medium	3/15	+3/16	+?4/22	+4/23	4/21 Heavy turbidity in supernatant liquid.
Litmus milk	3/15	−3/16	+3/22	+4/22	8/27 Grayish brown, 1 cm. prec. turbid above.
65F***	4/21	?4/22	−4/23	+4/24	4/21 All reduced, bluish ring at top, signs of peptonization from top down about 0.5 cm.
41F	4/21	?4/22	−4/23	+4/24	8/27 brown sediment.
36F	4/21	−4/22	−4/23	+4/24	8/27 flocculent precipitate.
34F	4/21	−4/22	−4/23	+4/24	
29F	4/21	?4/22	−4/23	+4/24	

***These humbers refer to the soil media numbered respectively in Fred's Soil Bacteriology laboratory manual.

The "ghost" or "phantom" colonies appeared in both plain and Dox's agar after 3 to 4 days. Since Dox's agar was slightly turbid the colonies were somewhat more easy to see because they were more clear than the medium. These colonies were never seen in a solid medium containing litmus or other indicator even when growth (gas formation) was very evident.

On 8/27 transfers were made into Dox's agar (see table 1) from inoculated media which had been incubating over 4 months at 60°–65°C with the following results, growth showing inside of 72 hours:

Cooked pork medium +
Gelatin agar −1.0 −
Soil extract agar +
Peptone solution plus lead acetate −
Corn agar + MR −
Hippuric acid solution +
Litmus milk +
Cider +
Mannit agar +
Starch agar + BTB +
Hay infusion +
Tryptophan broth +

Several days later the cultures marked with a negative sign also showed gas production, so 100 per cent of the cultures tested remained viable.

This interesting thermophile is a straight rod, motility not observed, single, in pairs and short chains; Gram negative, spores terminal or subterminal. In different media and at different stages of growth, "nodules" or enlargements are seen on the rods, it being impossible to determine whether they are located in any one place on the cell and whether a rod has more than one of them. Again, beaded forms are present, or masses containing small, deeply stained granules are seen which resemble very much the synplastic stage described by Löhnis.

Barlow's thermophiles from canned corn incubated at 60° and 70°C. were "gram negative, slender rods, single or united in two's, or in short and long threads." In practically every apparently sound can which swelled after incubation at 60° to 70°, this type of organism was the only type present in numbers sufficient to cause spoilage. Barlow observed neither spore formation nor motility in the organism described.

Experiments have not been performed to determine the maximum, minimum and optimum temperatures for Str. BIC but from observations during the course of its incubation the minimum of rapid growth is between 40° and 50°, the optimum from 55° to 65°; it is not killed by a temperature as high as 70°, the temperature at which the incubator was found one morning.

From the food standpoint this organism is important because it develops so rapidly and produces gas at high temperatures which would be inhibitive to common bacteria. In the canned beans from which it was isolated after the cans were processed (2½ hours only), the flame was turned off from beneath the wash boiler in which the cans were being heated and the cans left in the hot water until both the water and the cans with their contents were cool, which took several hours.

There is evidence, however, that this organism can grow at lower temperatures under certain conditions than 55° because of its invasion of, and multiplication in the blood stream of the guinea pig and also because of the large quantity of sediment found in the cans. In the latter case the growth must have proceeded very slowly indeed after the contents of the can had cooled to room temperature. This accounted for the failure of the organism to produce swells or leaks, or both, or to burst the cans.

In Part II of this bulletin mention is made of finding a similar organism in inoculated cans incubated at 55°.

The cans were submerged in water and the water kept at 55°. Along with these cans were kept unopened checks of each type of food. The examinations were made at the end of several months' incubation, results of which will be found in Table 4, Part II, of this bulletin.

In appearance the 55° cultures from these cans were identical with those isolated originally from string beans and from some silage. Also the rapid growth was characteristic. If cultures for cultivating at 55°-65° C. are made in hot agar (temperature within growing limits of thermophiles) and this agar is allowed to cool only sufficiently for solidification to start, then covered with sterile paraffin and placed at the incubating temperature the growth will be hastened much more than when the agar is allowed to become cold and wholly solid before incubating. It is necessary, however, that the agar be cooled until it starts to harden, before incubating, otherwise it will remain liquid and colony formation will not be seen.

In a recent study made of some experimental silage, plates made from it in acid whey and litmus dextrose agar plated and incubated at 55° showed active gas production but no visible growth just as in the case of the organism isolated from canned string beans. Isolations from these plates showed the same "ghostlike" colonies producing gas anaerobically. Although this coincidence has not been deemed of sufficient importance to determine whether the bacterium isolated from the silage and that from the string beans are the same organism, it does serve to show that an organism or organisms (anaerobic thermophiles having the peculiarities described) are not uncommon and are probably fairly well distributed in nature. The finding of organisms producing colonies of low visibility suggests that they may be common and not confined to anaerobic thermophiles. It is possible that ultra-microscopic organisms may produce this type of colony. Attention is called to the desirability of selecting the proper medium for this type of organism.

Since thermophiles are not infrequently found in canned foods and because of the discovery of this peculiarly growing anaerobic thermophile, it seems desirable (1) that the microbiologists in food research laboratories should make a practice of culturing all spoiled foods, canned or otherwise, both aerobically and anaerobically not only at room and body temperatures but also at a temperature sufficiently high to demonstrate the possible presence of thermophiles; (2) it seems that attention should be directed to the improvement of technic designed to overcome the difficulty of demonstrating organisms of low visibility of the type described or ultra-microscopic organisms.

SUMMARY

An anaerobic themophile was isolated from several cans of one pack of under-processed cold-packed string beans.

The liquor from the under-processed string beans was not found definitely to be poisonous to the experimental animals employed.

An odor fruity, even disagreeable, accompanies the growth of the anaerobic thermophile Str. BIC in all media, which odor, should this organism occur in canned food, would render the product not liable to be eaten, especially as the odor is intensified on heating.

The colonies which form in shakes of various agar media have about the same refractive index as the medium, and so are very difficult and in some cases impossible to see. In such media their presence has always been detected by the characteristic odor if the culture is old enough, and in many media by active gas production. The anaerobic thermophile described grows in practically all media tried experimentally.

So far as the literature on the thermophiles has been searched no reference has been found relating to an anaerobic thermophile, nor to an aerobic thermophile, nor to bacteria growing at ordinary temperatures, which have the above-mentioned peculiarity of growth, with the exception of those described by Bronson Barlow in his studies of thermophiles in canned corn.

CONCLUSIONS

So-called "flat sours" may be caused by bacteria which form acid, and perhaps so little gas that the ordinary glass-topped cans on opening by ordinary methods may fail to show its presence to the housewife, and metal-topped cans may fail to have the appearance of a "swell." It is improbable that flat sours of this type may be due to an anaerobic thermophile such as described in this paper since any considerable growth of this organism would produce a swell and not a flat sour.

Anaerobic thermophiles of this type are probably found in various places in nature; the fact that they have not been found previously is due to improper incubation, poor choice of media and the wrong method of obtaining anaerobic conditions.

BIBLIOGRAPHY

Barlow, Bronson.
Spoilage of Canned Corn due to Thermophilic Bacteria.
Master's Thesis, U. of Illinois, 1913.

PART II

Bacteriological Studies of Flat Sours of Cold Packed Canned Peas

ZAE NORTHRUP WYANT AND ROBERT L. TWEED

An attempt has been made to discover the organisms which cause flat sour of cold packed canned peas. No extensive bacteriological study of flat sour has been made up to the present time. Consequently, the available information both as to the nature and cause of flat sours is very limited.

In "Canners' Problems" (1) Bronson Barlow says:

"'Flat sours' are not caused by the heating and souring of corn before canning. Corn which was purposely allowed to heat and sour in the can was canned and was not flat sour. These cans did not develop flat sours on keeping." Barlow also says with regard to the organisms concerned: "Stains from flat soured corn show long, slender rods, often in chains."

In "The Canning of Fruits and Vegetables" (2) Zavalla makes the statement: "Spoilage due to insufficient processing is generally divided into two classes: swells and flat sours—flat sours most often result from giving the regular process to material which has been allowed to stand for some time, such as peas remaining in a load over night, or corn left in a car or in a pile until it begins to heat." The contradiction in the above references shows that the work on "flat sours" is still in an experimental stage.

In "Canning and Preserving of Food Materials" (3) by E. W. Duckwall, the author says:

"Sour peas in many cases are due to careless methods before the sterilizing process: there is no part of the process of pea-canning which affords so much danger of sour goods as the sweating of the vines and pods. One peculiarity of sour peas is that it is impossible to tell by the appearance that they are sour." Later he says: "I boiled twelve cans in an open bath for two hours, then put them in the incubator. Five spoiled within one day, three spoiled by the end of the second day, and two more swelled the following day. Two cans seemed to be all right. They did not swell, though kept at blood temperature for three weeks. On opening the cans, however, they were exceedingly sour. The color of the peas was much bleached, but otherwise they looked fairly well. I melted a flask of agar in the autoclav at 240°F. I inoculated two with several loops full of the liquor from these cans then made transfers from the first to two more, and from these made transfers into two more. I placed the dishes in the incubator, and at the end of twenty-four hours the first two dishes were completely covered with a thin growth extending even up to the walls. The next two dishes had a few colonies, but the greater portion of the surface was covered with a spreading growth. The two last dishes contained a few scattered colonies, which formed in wedge-shape below the surface and grew upward, forming thin, round colonies on the surface. Some of these colonies had a brown, opaque granular appearance by transmitted light, but on reaching the surface had a bluish cast with a shining transparent luster. The surface growth extended gradually to about the size of a silver three cent piece, the lustrous appearance giving way to a dull scum-like layer, quite viscous and forming folds or wrinkles, becoming much elevated.

"When transplanted to gelatin the colonies began to sink into the gelatin, in thirty-six hours leaving saucer-like depressions, and a floating film formed on the surface of the liquefied gelatin. The growth in the bouillon was rapid, producing very little cloudiness, a pellicle forming on the top which grew fast to the wall of the test tube. The bacilli were actively motile, exhibiting their motility in twisted, writhing masses.

"The cultures all had the odor of H_2S, and in a few days the sulfur would be strong enough to bleach out the blue color made with the blue pencil on the glass petri dishes and test tubes. I inoculated several cans of peas which had been sterilized, with some of these organisms, and in two or three days the cans had the same appearance and taste as the original two cans. I tested other cans by inoculating them with spores from the organism and processing at 240°F for twenty-five minutes. Of the twelve cans so treated only two were sterilized. Ten of these cans had a natural appearance, showed no sign of swelling, but turned sour in five days in the incubator. The spores of the organism are quite large, are situated near the middle, or perhaps a little nearer the end of the cell. The cell seems to split open at the side, setting the spore free."

Method Employed for Bacteriological Study of Flat Sour Peas

In order to simulate as closely as possible the composition of canned peas, a pea agar was prepared in the following manner:

1,000 gms. peas (canned).
4,000 c. c. water.
60 gms. agar.

The agar was boiled in water until dissolved. The water which had evaporated was replaced. The canned peas were mashed and added with their juice to the agar solution, and the medium was autoclaved for thirty minutes at fifteen pounds pressure. After autoclaving, the medium was cooled slowly. This allowed the broken skins and pulp to sink to the bottom, and when the agar had solidified the sediment was cut away and discarded. The remaining clear agar was melted, colored with litmus, and autoclaved.

The starch agar employed in this experiment was made according to the following formula:

Agar, 10 gms.
Diabasic potassium phosphate, 0.2 gms.
Magnesium sulphate, 0.2 gms.
Potassium carbonate, 0.4 gms.
Calcium chloride, 0.02 gms.
Ferric sulphate, 0.02 gms.
Sodium chloride, 0.02 gms.
Tap water, 500 c. c.
Starch solution, 500 c. c.

The mineral salts and agar were boiled together in tap water, the water which was lost in evaporation being replaced with distilled water. 500 c. c. of starch solution was added. The starch solution was made as follows: To 10 gms. of potato starch suspended in a little cold water 500 c. c. of boiling water was added. The solution was concentrated to 500 c. c. All other media used in this experiment were prepared according to the standard formulae.

The cans of peas examined were chosen from a number of so-called "flat sours" brought in by Mr. Glenn Kies, November 28, 1918. The cans were numbered III, IV and VII.

Can III. The contents of this can were slightly bleached. This condition is similar to that observed by Duckwall in canned soured peas. A white sediment was present in the bottom of the can. The peas had a distinctly sour taste. A slight vacuum was present. The pH values of the juice were determined by the colorimetric method.

Table 1.—pH of Pea Liquor in Cans Studied.

Normal Peas	6.2
Can III	4.8
Can IV	5.3
Can VII	5.3

Can IV. This can was normal in appearance, and showed a slight vacuum. Can VII was identical with Can IV in appearance and in the behaviour of the plates.

All the cans used were treated in the following manner: The whole can was first washed in water, then the cover and neck were immersed, top side down, in 1-500 mercuric solution for five minutes; then a little alcohol was poured on the cover and burned.

The three cans numbered III, IV and VII were opened, plated by the loop dilution method and incubated both aerobically and anaerobically at 20°, 37° and 55° C. respectively.

The anaerobic plates were made as follows: After the inoculated plate was poured and had hardened a second tube of melted pea agar was poured over the solid medium. When this hardened it was covered with a layer of melted paraffin, which had been previously heated until smoking hot, then cooled to about 60° C.

Plates from the three cans gave the following results:

Can IV. No colonies developed.

Can VII. Same as IV. Cans IV and VII apparently were sterile.

Can III. Plates contained acid colonies in twenty-four hours at 37° and 55°, and in forty-eight hours at 20°.

Isolations of acid-forming colonies were made in pea agar shakes.

I. 37° aerobic—2 thin spreading colonies.
II. 37° aerobic—2 colonies.
III. 55° aerobic—3 colonies are coarsely granular, near margin and have a finely granular center which protrudes above the surface.
IV. 55° aerobic—3 small, wrinkled, white colonies.
V. 37° anaerobic—2 colonies—look like subsurface colonies of *Bacterium lactis acidi*.
VI. 55° anaerobic—3 thin, concentrically ringed colonies.
VII. 55° anaerobic—3 thin, spreading colonies.
VIII. 20° anaerobic—1 very transparent colony.
IX. 20° aerobic—1 translucent, white colony.
X. 20° aerobic—1 subsurface colony.
XI. 20° aerobic—transparent white colony.
XII. 20° aerobic—1 colony with crumpled white surface.

Triplicate cultures of each of the above described colonies were made in pea agar shakes and a tube of each organism was placed at 55°, 37°, and 20°. The growth was equally abundant at all three temperatures although slightly slower at 20°.

Growth in the pea agar shakes was well distributed throughout the tubes in all cases. The medium throughout the whole tube became acid. In a few days a slight surface growth appeared. The growth in all the tubes looked very much alike. There was no gas formation.

To make sure the cultures were pure the pea agar shakes were again plated out in pea agar, aerobically. After incubation for twenty-four hours at 37°, isolations were made in broth.

Two general types of colonies were found which will be called A and B.

Isolations from aerobic pea agar plates:

A—Concentrically ringed colonies.
B—Smooth, round colonies.

The types were found on the plates as indicated in this list:

I—A, B.
II—A, B.
III—A, B.
IV-V—Sterile.
VI—A, B.
VII—B.
VIII—A, B.
IX—A, B.
X—Too thick.
XI—A, B.
XII—Pure, neither A, B. nor C.

From the above organisms seven representative pure cultures were selected for study because time was too limited for a study of the whole group.

These organisms all form a thick, viscous, wrinkled membrane on the surface of the broth.

Three day broth cultures of these organisms were examined microscopically with the following results:

I. A. Long parallel filaments. Shorter ones actively motile.
I. B. Motile rods, single and in chains. Growth not thick.
VI. A and B. Like I B.
VII. B. Like I B. Occasional long filaments.
VIII. A. Like I. B.
XI. A. Like I. B.

Each of these organisms was inoculated into all the ordinary culture media.

In the study of these organisms determinations were made as follows:

1. Microscopic examination for vegetative cells on three day broth culture grown at 20°C.
2. Spore examination on twenty-one day broth culture grown at 20°C.
3. Aqueous-alcoholic and gram stains on three day broth culture grown at 20°.
4. Thermal death point determination of twenty-one day broth culture grown at 20°C.

All media used had the reaction of +1.5.

All cultures except gelatin stabs were kept at room temperature. The gelatin stabs were kept at 15°C.

ORGANISMS ISOLATED

Bacillus I A

I. Morphology:

1. Vegetative cells.
   Slender rods with rounded ends. Occur singly and in short chains.
2. Endospores.
   Position—near one end.
   Form—oval.
   Spores were found in broth.
3. Motility.
   Actively motile.
4. Staining.
   Stains well with methylen blue.
   Gram negative.

II. Cultural Characteristics:

1. Agar Slant.
   Growth scanty, filiform, slightly raised, glistening, smooth, translucent, white, odorless, slimy.
2. Gelatin stab:
   Growth best at top; beaded; liquefaction saccate, becoming stratiform, liquefied part clear.
3. Broth culture:
   Wrinkled, membranous surface growth, slimy; no clouding.
4. Potato Culture:
   Abundant growth in form of "water blisters" or blebs.
   Slimy, slightly pink tinge.
5. Litmus milk.
   Slimy, neutral, curded. Peptonization begins in six days.

III. Physical and biochemical features:

1. Temperature relations.
   Grows best within the temperature range of 37°-55°C, but also grows well at 20°C. Killed at 110°C. for 10 minutes.

Bacillus I B

I. Morphology:

1. Vegetative Cells:
   Slender rods occurring singly and in filaments.
2. Endospores:
   Position—near one end.
   Form—oval.
   Spores found in broth culture and agar slant.

3. Motility:
   Actively motile.
4. Staining:
   Stains well with methylen blue. Gram negative.

II. Cultural Characteristics:

1. Agar slant:
   Growth scanty, filiform, raised, glistening, smooth, translucent, white, odorless, slimy.
2. Gelatin stab.
   Growth best at top. Liquefaction saccate and stratiform.
3. Broth Culture:
   White, wrinkled, slimy membrane over top of broth.
4. Potato Culture:
   Transparent blebs, becoming opaque. Slimy, grayish-white.
5. Litmus milk.
   Slimy, neutral curd. Much peptonization in six days.

III. Physical and biochemical features:

1. Temperature relations:
   Optimum temperature range 37°-55°C. Grows well at 20°C.
   Killed by heating at 80° ten minutes.

Bacillus IV A

I. Morphology:

1. Vegetative cells:
   Slender rods occurring singly and in chains.
2. Endospores:
   Position—near one end.
   Form—oval.
3. Motility:
   Motile.
4. Staining:
   Stains well with methylen blue. Gram negative.

II. Cultural Characteristics:

1. Agar stab:
   Growth abundant, filiform, raised, glistening, smooth, translucent, creamy white, slimy.
2. Gelatin stab:
   Growth best at top, beaded. Liquefaction—crateriform becoming stratiform. Begins in 3 days.
3. Broth Culture:
   Wrinkled, slimy, white membrane.
4. Potato Culture:
   Growth abundant, beaded, raised, cretaceous, slimy.
5. Litmus milk:
   Slimy, neutral, and slow peptonization.

III. Physical and Biochemical Features:

1. Temperature relations:
   Optimum temperature 37°-55°C. Grows at 20°C.

Bacillus VI B

I. Morphology:

1. Vegetative cells:
   Rods occurring singly and in chains.
2. Endospores:
   Position—near one end.
   Form—oval.
3. Motility:
   Actively motile.
4. Staining:
   Stains well with methylen blue. Gram negative.

II. Cultural Characteristics:

1. Agar slant:
   Growth scanty, filiform, flat, glistening, smooth, translucent.
2. Gelatin stab:
   Growth best at top. Liquefaction—whole tube softened.
3. Broth culture:
   Slimy membranous surface growth.
4. Potato culture:
   Moderate growth in form of water blisters or blebs. Transparent at first, becoming opaque. Slimy.
5. Litmus milk:
   Litmus reduced in four days.

III. Physical and Biochemical Features:

1. Temperature relations:
   Optimum temperature range 37°-55°C. Grows well at 20°C.
   Killed by exposure at 90°C for ten minutes.

Bacillus VII B

I. Morphology:

1. Vegetative cells. Rods single and in chains. Occasional long filaments.
2. Endospores:
   Position—near end.
   Form—oval.
3. Motility:
   Actively motile.
4. Staining:
   Stains well with methylen blue. Gram negative.

II. Cultural Characteristics:

1. Agar Slant:
   Growth abundant, filiform, flat, glistening, smooth, translucent, slimy.
2. Gelatin stab.
   Growth plumose. Distinct star-shaped colonies. No liquefaction.
3. Broth Culture:
   Slimy membranous growth.
4. Potato Culture:
   Abundant, spreading, glistening, smooth, white, slimy growth.
5. Litmus milk:
   Slimy neutral curd.
   Slow peptonization.

III. Physical and Biochemical Features:

1. Temperature relations:
   Optimum temperature, 37°-55°C. Grows well at 20°C.
   Killed by exposure to a temperature of 100°C for 10 minutes.

Bacillus VIII A

I. Morphology:

1. Vegetative cells:
   Slender rods occurring singly and in filaments.
2. Endospores:
   Position—near one end.
   Form—oval.
3. Motility:
   Motile.
4. Staining:
   Stains well with methylen blue. Gram negative.

II. Cultural Characteristics:

1. Agar slant:
   Growth moderate, filiform, raised, glistening, contoured, translucent, creamy, slimy.
2. Gelatin stab:
   Growth best at top, beaded, liquefaction saccate, becoming stratiform, begins in three days.
3. Broth culture:
   Wrinkled, white, slimy, membranous surface growth.
4. Potato culture:
   Transparent slimy blebs becoming opaque in three days.
5. Litmus milk:
   Slimy, rennet curd. Slow peptonization.

III. Physical and Biochemical Features:

1. Temperature relations:
   Optimum temperature range 37°-55°C. Grows well at 20°C.

Bacillus XI A

I. Morphology:

1. Vegetative cells:
   Slender rods occurring singly and in short filaments.
2. Endospore:
   Position—near end.
   Form—oval.
3. Motility:
   Actively motile.
4. Staining:
   Stains well with methylen blue. Gram negative.

II. Cultural Characteristics:

1. Agar Slant:
   Growth moderate, filiform, raised, glistening, smooth, opaque, white, slimy.
2. Gelatin stab:
   Growth best at top. Liquefaction stratiform, liquefied part clouded.
3. Broth culture:
   Slimy, white membrane on surface.
4. Potato culture:
   Growth like water blisters; transparent becoming opaque. Faintly pink.
5. Litmus milk:
   Slimy rennet curd. Rapid peptonization.

III. Physical and Biochemical Features:

1. Temperature relations:
   Optimum temperature range—37°-55°C. Grows well at 20°c.

All the organisms were inoculated into tubes of peas covered with sterile paraffin oil and incubated at the three temperatures employed previously and the juice of each tested for its pH value with the following results:

Table II.—PH of Pea Liquor in Inoculated Tubes

Organism.	pH after 10 days at 55°.	pH after 7 days at 20°.	pH after 20 days at 20°.
I A	6.0	5.8	5.8
I B	5.8	5.8	5.8
VI A	5.9	6.0	6.0
VI B	5.9	5.7	5.6
VII B	5.9	5.6	5.7
VIII A	6.0	6.0	6.0
XI A	5.4	5.9	5.9

In all but one case rise in acidity was as rapid or even more rapid at 20° than at 55°. This would indicate that a souring caused by these organisms would develop at room temperature as readily as at higher temperatures.

Starch agar was poured into sterile petri dishes and allowed to harden. Aerobic streaks of each organism were made and incubated at 37°. The solvent action of the organisms on starch was determined by the iodine reaction and recorded after twenty-four hours growth.

Cultures I B, VIII A, VII B and XI A produces a zone of starch digestion from 2 to 8 mm. in width. These five cultures were all alkaline to C-R (China-blue-rosolic acid) in the starch agar.

Anaerobic starch digestion was determined by making plates as above, then covering with melted agar and sterile paraffin. Starch digestion was determined as above after four days at 20°C.

These same cultures grown under anaerobic conditions showed much wider areas of starch digestion. VI A and VIII A reacted distinctly acid to C-R. I A was pink to iodine showing the presence of erythrodextrin. VI B showed only very slight starch digestion anaerobically.

Cultures I A, I B, VI B and VII B organisms were slected from the seven studied, for thermal death point determinations. The remaining three were eliminated because they seemed to be identical with one of the four selected, and also because lack of time prevented complete investigation.

Twenty-one day broth cultures grown at 20° were used for thermal death point determinations. Duplicate tests were made of each organism in ten minute holding periods.

Table III.—Thermal Death Point Determinations of Cultures Isolated

	After 48 hours incubation.						After 72 hours incubation.					
	70°	80°	90°	100°	110°	120°	70°	80°	90°	100°	110°	120°
L A-1	+	+	+	+	+	−	+	+	+	+	.....	.....
L A-2	+	+	+	+	+	−	+	+	+	+	+	.....
I B-1	.....	.....	.....	.....	.....	−	+	+	+	.....	.....	.....
L B-2	.....	+	.....	.....	.....	−	+	+	+	.....	.....	.....
VI B-1	+	....	.....	.....	....	−	+	.....	.....	.....	.....	.....
VI B-2	+	+	+	.....	.....	−	+	+	+	.....	.....	.....
VII B-1	+	+	+	+	.....	−	+	+	+	+	.....	.....
VII B-2	+	+	+	.....	.....	−	+	+	+	.....	.....	.....

Cultures I A and VII B seem to be quite resistant to heat. I B resists a temperature of 90° for ten minutes. VI B is killed at a lower temperature of 80°. In general, the thermal death point seems to be above 80° and below 110°C.

Sterile cans of string beans, lima beans, corn, peas, pumpkin, and tomatoes were inoculated with each of the four organisms used above in triplicate. One set was incubated at 20°, 37° and 55°C respectively. Uninoculated opened and unopened controls also were placed at 20° and 37°. Only unopened controls were placed at 55°.

The cans were inoculated during the latter part of March, 1920, and the observations taken in November of the same year on the 20° cans seem to indicate that the organism introduced into the can in quite a few cases could cause not a flat sour but a swell. Some of the checks, however, both unpened and opened, also swelled.

There seemed to be more spoilage in the opened than in the unopened checks. Two explanations may be offered for this occurrence and it would be extremely difficult to prove which was right. Either organisms were introduced accidentally on opening the can through the drawing in of air when the vacuum is destroyed or the destruction of the vacuum allowed the entrance of air thus encouraging organisms already present and dormant which needed a certain amount of air for growth. This latter explanation is the more probable and covers the conditions in the 37° checks also.

So far as the records show, there is more spoilage in the 37° cans than in the 20° cans, and what is more interesting, there is more spoilage in the 55° cans than in the 37° cans. This suggests either that the optimum for the organisms introduced lies nearer 55° than 37°, or that thermophilic bacteria (not the ones introduced as these are not true thermophiles) are hard to kill by the ordinary processing methods and that they remain dormant under ordinary methods of storage.

The conclusions may be drawn at this time: First, that cans after processing should be cooled as rapidly as is consistent with the type of container, and then that the storage temperature be below 20° if possible.

The 55° degree cans were opened in March, 1921, one year following inoculation, cultured and studied since these data were desired as an addition to the data on thermophiles already accumulated. Due to lack of time the 37° and 20° cans were not opened until August, 1922.

All of the cans were treated as follows: the tops were washed with 1-500 mercuric chloride, a hole large enough for inserting an inoculating needle was punctured in the top near the edge, the presence of gas being noted at the time; then two cultures were made, one a shake in plain dextrose agar under oil for high temperature cultivation, and the other a shake-slant in dextrose agar plus brom thymol blue for 37° incubation. The top was then removed and the color, appearance, odor, consistency and pH of the contents noted.

Table IV.—Showing Condition of 55° Cans When Opened March, 1921

Culture Number.	Material in can.	Condition of cans.	Gas on puncturing.	Color.	Appearance.	Odor.	Consistency.	pH.
I A	Lima Beans	Tight swell	+	Normal	Gas bubbles on top	O. K	Inside of beans all or partially gone.	6.3
I A	String Beans	O. K	–	Cloudy white	Inside of can corroded. Beans white.	Fruity	Soft	6.1
I A	Corn	Tight swell	+	Normal	Corn germs on top	O. K	Normal	6.4
I A	Peas	O. K	–	White	Mold on top. Inside of top corroded.	Sourish	Cheesy-like	6.1
I A	Pumpkin	Double springer	+	D. brown	"Craters" on top	O. K	Sugar probably carmelized by heat.	6.2
I B	Lima Beans	Springer and leaky.	–	Brown and grayish	Juice gone. Inside of can rusted.	Sour, unpleasant	Beans ruptured	6.2
I B	String Beans	Springer	+	Cloudy	O. K. except cloudy	O. K		5.8
I B	Corn	Springer	+	Darker than 1 A	Corn germs on top	O. K	O. K	6.0
I B	Pumpkin	Tight double swell.	+	Lighter than 1 A	Two-thirds full. "Craters" on top.	O. K	Dry	6.0
I B	Tomatoes	Tight swell	++ Juice spurting	D. brown	Bubbles to top on stirring	O. K	Pulp finely granular	6.2
VI B	Lima Beans	Tight double swell.	++	Cloudy juice	Bubbles on top. Speckled appearance.	Uncooked green bean	Most beans ruptured	6.1
VI B	String Beans	Springer	++ Juice spurting	Cloudy	Mouldy on top showing leakage	O. K	Soft	6.6
VI B	Corn	Springer	+	Cloudy	Corn germs on top	O. K	Normal	6.2
VI B	Peas	Springer	+–	Cloudy	Sediment	O. K	Firm	6.1
VI B	Pumpkin	Tight double swell.	++	O. K	Small "craters"	O. K	Normal	6.2
VI B	Tomatoes	Springer	–	D. brown	Two-thirds full. Inside of can badly corroded.	Unpleasant	Normal	6.1
VII B	Lima Beans	Swell and leak	–		Beans caked	Musty	Beans badly ruptured	6.1
VII B	String Beans	O. K	+–	O. K	Juice clear	O. K	Firm	6.0
VII B	Corn	O. K	–	O. K	Normal	O. K	Normal	6.0
VII B	Peas	Tight double swell.	++ Juice spurting	Brown	D. brown spots on peas	Normal	Many peas split with gas.	6.1
VII B	Pumpkin	Tight double swell. Burst along seam.	–	Greenish blackish	Inside corroding Pumpkin sticking.	Normal	Normal	6.0

Table IV.—(Continued)

VII B..........	Tomatoes.....	Tight double swell.	++	Black.............	Tomatoes putrid..............	Putrid..............	Soft..................	6.4
Unopened control.	Lima Beans...	Tight swell.......	+	Brownish..........	Beans full of gas	–	Beans ruptured..........	6.1
Unopened control.	Tomatoes.....	Tight swell.......	+	Dark..............	Good.........................	Normal..............	Normal................	6.2
Unopened control.	Peas.........	O. K............	±	Normal............	Brown spot in peas...........	Disagreeable..........	Peas firm..............	6.1
Unopened control.	Pumpkin.....	Full of pin holes. Badly rusted.	–	D. brown..........	Moldy contaminated..........	Musty..............	Soft and musty.........	6.1

Note: Minus sign=no gas. ± =very little gas. + =A little gas. ++ =A large amount of gas.

Table V.—Shows Condition of 37° Cans When Opened August, 1922

Culture Number.	Material in can.	Condition of cans.	Gas on puncturing.	Color.	Appearance.	Odor.	Consistency.	pH.
I A	Lima Beans	O. K	+−	O. K	Gas bubbles	O. K	Normal	5.6
I A	String Beans	Swell	+	O. K	Can corroded. Beans broken	O. K	Soft	5.6
I A	Corn	O. K	−	O. K	Normal	O. K	Normal	5.8
I A	Peas	O. K	−	O. K	Normal	O. K	Normal	5.6
I A	Pumpkin	O. K	−	O. K	Gas bubbles	O. K	Normal	5.8
I A	Tomatoes	O. K	−	D. brown	Two-thirds full, brown	Burned	Decomposed	7.2
I B	Lima Beans	Double tight swell	++	Brown	Gas bubbles and gas in beans	Burned	Beans ruptured	6.0
I B	String Beans	O. K	−	O. K	Normal	O. K	Good	5.6
I B	Peas	O. K	−	O. K	Normal	O. K	Good	5.8
I B	Pumpkin	Double tight swell	++	O. K	Normal	O. K	Good	6.6
I B	Tomatoes	O. K	−	O. K	Normal	O. K	Good	5.8
VI B	Lima Beans	Swell	++	Bleached	Gas bubbles	Sour	Beans broken and soft	5.6
VI B	String Beans	O. K	−	O. K	Normal	O. K	Normal	5.6
VI B	Corn	O. K	+	O. K	Normal	O. K	Normal	5.6
VI B	Peas	Swell	+	O. K	Normal	O. K	Normal	5.6
VI B	Tomatoes	Springer	+−	O. K	Normal	O. K	Normal	5.6
VII B	String Beans	O. K	−	O. K	Normal	O. K	Normal	5.8
VII B	Pumpkin	O. K	−	O. K	Normal	O. K	Normal	6.8
VII B	Tomatoes	O. K	−	Bleached	Moldy and dry	O. K	Dry	5.8
Opened control	Lima Beans	O. K	+−	O. K	Normal	O. K	Normal	6.0
Opened control	String Beans	O. K	−	O. K	Normal	O. K	Normal	6.0
Unopened control.	Lima Beans	O. K	−	O. K	Normal	O. K	Normal	6.0
Unopened control.	String Beans	O. K	−	O. K	Normal	O. K	Normal	6.0
Unopened control.	Corn	Springer	+−	O. K	Normal	O. K	Normal	5.8
Unopened control.	Pumpkin	Swell	+	O. K	Normal	O. K	Normal	6.4
Unopened control.	Tomatoes	O. K	−	O. K	Normal	O. K	Normal	5.6

Table VI.—Shows Condition of 20° Cans When Opened August, 1922

Culture Number.	Material in can.	Condition of cans.	Gas on puncturing.	Color.	Appearance.	Odor.	Consistency.	pH.
I A	Lima Beans	O. K	+	Bleached	Beans swollen and filled with gas.	O. K	Beans gassy	5.8
I A	String Beans	O. K	–	O. K	Normal	O. K	Normal	5.8
I A	Corn	O. K	–	O. K	Normal	O. K	Normal	5.8
I A	Peas	O. K	–	O. K	Normal	O. K	Normal	5.8
I A	Pumpkin	O. K	–	O. K	Normal	O. K	Normal	6.0
I A	Tomatoes	O. K	–	O. K	Normal	O. K	Normal	5.6
I B	Lima Beans	O. K	–	O. K	Normal	O. K	Normal	5.8
I B	String Beans	O. K	–	O. K	Normal	O. K	Normal	5.8
I B	Corn	O. K	–	O. K	Normal	O. K	Normal	5.8
I B	Peas	O. K	+	Bright green	Gas bubbles	O. K	Soft	5.6
I B	Tomatoes	O. K	–	O. K	Normal	O. K	Normal	5.6
VI B	Lima Beans	O. K	+	O. K	Normal	Sour	Normal	5.8
VI B	String Beans	O. K	–	O. K	Normal	O. K	Normal	5.8
VI B	Corn	O. K	–	O. K	Normal	O. K	Normal	6.2
VI B	Peas	O. K	++	O. K	Normal	O. K	Normal	5.8
VI B	Pumpkin	O. K	–	O. K	Normal	O. K	Normal	6.4
VI B	Tomatoes	O. K	–	O. K	Normal	O. K	Normal	5.8
VII B	String Beans	Springer	+	O. K	Normal	O. K	Normal	5.8
VII B	Pumpkin	O. K	–	O. K	Normal	O. K	Normal	6.4
VII B	Tomatoes	O. K	–	O. K	Normal	O. K	Normal	5.8
Unopened control.	Lima Beans	O. K	–	O. K	Normal	O. K	Normal	6.2
Unopened control.	String Beans	O. K	–	O. K	Normal	O. K	Normal	5.8
Unopened control.	Corn	O. K	–	O. K	Normal	O. K	Normal	6.4
Unopened control.	Peas	O. K	–	O. K	Normal	O. K	Normal	6.2

Table VI.—(Continued)

Unopened control.	Pumpkin.....	O. K............	−	O. K..............	Normal......................	O. K................	Normal................	6.6
Unopened control.	Tomatoes.....	O. K............	−	O. K..............	Normal......................	O. K................	Normal................	6.0
Opened control...	Lima Beans...	O. K............	+−	O. K..............	Normal......................	O. K................	Normal................	6.2
Opened control...	Corn.........	O. K............	−	O. K..............	Normal......................	O. K................	Normal................	6.0
Opened control...	Peas.........	O. K............	−	O. K..............	Normal......................	O. K................	Normal................	6.2
Opened control...	Pumpkin.....	O. K............	++	O. K..............	Gas bubbles..................	O. K................	Normal................	6.2

Table VII.—Records of Cultures From Inoculated Cans

Cult. No.	Material in can.	65° shake plain.	37° shake-slant + BTB.
I A	Lima Beans	Gas + in 5 hrs. No visible colonies even later	No growth.
I A	String Beans	No gas, no colonies visible	Mold and bacterial growth. (IA?) 2 days. Acid reaction.
I A	Corn	No gas. A few very small colonies (IA?)	No growth.
I A	Peas	Colonies (IA?) but no gas	2 days, acid reaction, full of bacterial colonies, molds ++.
I A	Pumpkin	Gas + 5 hrs. No visible colonies	No growth.
I A	Tomatoes	Can gone	
I B	Lima Beans	Gas ++ 5 hrs. Full of small colonies 2 days (IB?).	2 days, many acid colonies.
I B	String Beans	Gas + 5 hrs. 2 days. A few very small colonies.	1 small colony on surface.
I B	Corn	Gas ++ 12 hrs. No visible colonies	No growth.
I B	Peas	Can gone	
I B	Pumpkin	Gas + 12 hrs. No visible colonies	No gas. Growth doubtful.
I B	Tomatoes	Gas + 5 hrs, ++ 12 hrs. No visible colonies	2 or 3 yellow colonies. Many molds.
VI B	Lima Beans	Gas ++ 5 hrs. Only 2 visible colonies	Molds only, acid.
VI B	String Beans	Gas + 5 hrs, ++ 12 hrs. No visible colonies	Molds only, acid.
VI B	Corn	No gas or visible colonies	No growth.
VI B	Peas	Gas ± 2 days. No visible colonies	No growth.
VI B	Pumpkin	No growth	No growth.
VI B	Tomatoes	Gas +++ 5 hrs. No visible colonies. A mold colony on surface.	Molds and acid bacterial colonies.
VII B	Lima Beans	Gas + 5 hrs. 2 days. Quite a few very small colonies (VII B?).	Many acid colonies.
VII B	String Beans	No growth	No growth.
VII B	Corn	No gas or growth	No growth.
VII B	Peas	Gas + 12 hrs. No visible colonies	No growth.
VII B	Pumpkin	No gas but full of fine colonies (VII B?)	Many acid colonies.
VII B	Tomatoes	Gas ± 36 hrs. No visible colonies	Many acid colonies.
Check	Lima Beans	No gas or visible colonies	Full of very small acid colonies.
Check	Peas	No gas or visible colonies	No growth.
Check	Pumpkin	Full of small colonies, gas in oil only	No growth.
Check	Tomatoes	No gas	No growth.

If we consider a "flat sour" to be an apparently normal can, the contents of which have a hydrogen-ion concentration above 5.8* without the pro-production of any gas, or of only a very small quantity, it will be noticed from Table IV that no flat sours were developed in the cans incubated at 55°C.

I B String Beans, having pH of 5.8 was a springer, therefore cannot be considered as a flat sour. Other inoculated cans in this set having a pH as high as 5.8 were either tight swell or apparently normal.

In Table V we find that I A, Lima Beans; I A, Corn; I A, Peas; I A, Pumpkin; I B, String Beans; I B, Peas; I B, Tomatoes; VI B, String Beans; VI B, Corn; VII B, String Beans, and VII B, Tomatoes, all have a hydrogen-ion concentration of 5.8 or above, and all except tomatoes may be considered as being flat sours. The unopened tomato control has a pH of 5.6, therefore the inoculated tomatoes mentioned above could not be considered flat sours.

Organisms I A and VII B both apparently produced flat sours in corn, while I A and I B both apparently produced flat sours in peas, and VI B and VII B in string beans incubated at 37°C.

From Table VI it will be noticed that all four organisms produced the greater number of flat sours at 20°C. By subsequent test thermophiles developed.

It is quite evident from Table IV that nothing but thermophiles developed in the cans incubated at 55°C. The cultures in many of these cans contained a thermophile resembling Str. B I C, an anerobic thermophilic organism isolated from string beans described in Part I, page 6. They showed gas and a few almost invisible colonies, producing minute gas bubbles and referred to by Z. N. W. as "ghost" colonies.

It is very doubtful whether any of the organisms developing in the cultures kept at 65°C were those placed in the 55° cans, since the incubating temperature employed was 10 degrees higher than the storage temperature of the cans.

One of the writers (Z. N. W.) believes that the thermophiles developing in the cultures were already in the cans when incubated since no preliminary incubation of the cans was made.

---

*i. e., pH reading below 5.8.

SUMMARY AND CONCLUSIONS

1. Organisms resembling aerobic spore-forming soil organisms may cause flat sours when grown under anaerobic conditions, such as we have in canned goods.

2. The organisms studied are more likely to produce flat sours at room temperatures than at 37° or 55°C.

3. The organisms causing flat sours in the experiments cited are killed by exposure to a temperature of 110°C. for ten minutes.

4. The entire contents of the original cans of peas did not reach a sufficiently high temperature or were not kept at 100° for a sufficiently long time to destroy the spores of the isolated organisms.

5. The organisms under the conditions studied are favored by temperatures of 20° to 37°. Therefore flat sours may develop (1) when blanched products are allowed to stand, (2) when cans are not cooled quickly after processing, and (3) when storage temperature is too high. In both of the latter cases the assumption is that the product is not sterile.

6. From a scientific standpoint it would be well to sterilize all canned goods, but from a practical standpoint this may not be advisable. All cans, however, should be cooled rapidly after being processed and stored at a low temperature.

7. Thermophiles may cause flat sours if the temperature of the food products is sufficiently high for a long enough time to allow thermophiles to develop. The indications from these experiments are that this is not probable as the thermophiles encountered did not cause flat sours.

BIBLIOGRAPHY

(1) Canners' Problems, Unpublished Thesis, Univ. of Illinois, 1913.
(2) Canning of Fruits and Vegetables—Zavalla, J. P., p. 53, John Wiley and Sons. N. Y., 1916.
(3) Canning and Preserving of Food Products—Duckwall, E. W., pp. 348-354 and 369, Pittsburgh Printing Co., Pittsburgh, Pa., 1905.
(4) Journal of Bacteriology, Vol. I, 1916, pp. 273-321 and 493-533.

FOREWORD

Bacteriology has made notable contributions to Dairy Science. Market milk production is influenced largely by practices dictated by bacteriological research. Dairy manufactures, particularly in the field of butter and cheese making, are dependent on the results of bacteriological investigations. Condensed milk of various types has received some attention at the hands of the bacteriologist and fermented milk drinks have been studied rather extensively. Nearly all these investigations have been the result of the combined efforts of the research workers of all countries having a dairy industry. Ice cream manufacture, however, has been neglected by the bacteriologist with the result that the literature on the subject is very limited and unsatisfactory and there are not available numerous or satisfactory data on which to base an understanding of the bacteriology of the many processes involved in the manufacture of this very important food. The fact that ice cream is not widely used outside of North America may account for the wide-spread neglect of this dairy product on the part of foreign bacteriologists.

Mr. Fabian has already endeavored to perfect a score card* for ice cream plants and he has studied milk production and transportation from the standpoint of supplying the ice cream manufacturer. In this bulletin he undertakes to follow the raw materials of ice cream through all the processes of manufacture using the plate method to determine the changes in bacterial content. This work is only preliminary to a more detailed study now under way having in view the improvement in the technic for the studies and the elucidation of many points not made clear in this paper.

WARD GILTNER.

---

*A score card for city ice cream plants. Jour. Dairy Sci., Vol. III, No. 3., pp. 230-235, 1920.

THE INFLUENCE OF MANUFACTURING OPERATIONS ON THE BACTERIAL CONTENT OF ICE CREAM

FREDERICK W. FABIAN AND ROY H. CROMLEY

Technical Bulletin No. 60

INTRODUCTION

The importance of ice cream as a food is daily increasing. The manufacture of ice cream has risen from a back-door and cellar industry to one of great importance. From a preliminary statement from the Census Bureau of the United States Department of Commerce the following statistics are available: From 3,476 establishments engaged in the manufacture of ice cream in 1919 were reported products valued at $189,414,000. This is compared with 1914 in which year 2,437 establishments reported products valued at $55,983,000. This represents an increase of 238 per cent in value over a five year period. In Michigan between 1914 and 1919, the ice cream industry shows a growth from 60 establishments manufacturing a product worth $1,803,000 in 1914, to 92 establishments whose product was valued at $5,302,000 in 1919, or an increase of 194 per cent in value over a five year period.

It will thus be seen that the importance of ice cream as a food has increased considerably in the past five years. As the consumption of ice cream increases no doubt there will be more detailed studies made of it from the chemical and bacteriological standpoint. The chemical composition is fairly well defined in most states but there is a conspicuous lack of bacteriological standards at the present time. There seems to be no well defined sanitary code as in the case of milk and water. As our sanitary knowledge of ice cream increases so that an intelligent standard will be possible, such a sanitary code will be forthcoming. One of the important things that a sanitary code will have to take into consideration is the influence of the manufacturing operations on the bacterial count.

Such a study not only reveals the sanitary quality of the product, but also tells something of the methods employed in making the ice cream.

PREVIOUS WORK

Pennington and Walter (1) were among the first investigators to make a bacteriological study of each step in the process of manufacturing ice cream. Only one sample was analyzed, however, so that no definite conclusions were drawn. They reported that although the cream was pasteurized twice, once before it reached the city and again as soon as it was received, "nevertheless vegetative streptococci are found in the finished process." Continuing they say that, "the proportion of streptococci as compared with other organisms in the finished ice cream is strikingly high."

Hammer (2) investigated the number of bacteria at various stages in the manufacture of ice cream and concluded "that it is possible to produce ice cream in quantities, up to 20 gallons at least, with a low bacterial count without expensive methods, though it is not certain that this is true under large factory conditions." Hammer and Goss (3) studied the influence of freezing, hardening, and storage on the bacterial content of ice cream and concluded that, "there is no evidence that there is an increase in the numbers of contained organisms during the proper storage of ice cream while commonly there is a decrease." Their results were based on colonies developing on agar held at 37° C for 48 hours. They also say that, "there is an apparent increase in the number of bacteria as determined by the plate method during the freezing of ice cream." Concerning the process of hardening they found that, "there is usually a decrease in the number of bacteria in ice cream during the hardening process, presumably as a consequence of the destructive action of the lowered temperatures."

In a continuation of the study of bacteria in ice cream Hammer and Sanders (4) studied the influence of pasteurization and homogenizing upon the bacterial content of the ice cream mix and report as follows: "The pasteurization of the mix reduced the bacterial content very satisfactorily. The method of pasteurizing and homogenizing the mix should be considered as satisfactory for the production of ice cream with a low bacterial count."

Peterson and Tracy (15) made bacterial counts on two batches after the completion of each step in the manufacturing process to determine the relative importance of each step. Their results indicate "that after the mix is drawn from the pan the subsequent steps in the operation will result in the addition of only a very small number of bacteria if ordinary precautions are taken against recontamination. The increase after homogenizing and freezing is probably due, for the most part, to the breaking up of the bacterial clusters, which results in a higher count by the plate method."

The influence of storage upon the bacterial content of ice cream has been studied by several workers. Stiles and Pennington (5), Gordon (6), Hammer (2), Esten and Mason (7) and Ellenberger (8) and others have worked upon this phase of the problem and covered it quite completely.

PRESENT WORK

The present work is a study of the influence of the various manufacturing operations upon the number of bacteria in vanilla ice cream made under factory conditions. The samples of the various batches were taken at random from the first of September to the first of July. The workers in the factory were not aware that any attempt was being made to check the sanitary quality of their work. As a matter of fact samples of ice cream were taken daily at this plant for fat determinations and bacterial counts, so that their suspicions never were aroused so as to induce them to take any unusual sanitary precautions to produce ice cream of low bacterial count. The authors believe that the work presented in this paper represents what can be expected in a sanitary way from a commercial ice cream factory. This particular factory was chosen for this work because to our minds it represented an average up-to-date factory. The output is not as great as that of the largest factories, nor is the output so small as to exclude piping and other necessary machinery, not usually found in small factories, but which may be a great source of bacterial contamination. The output averages about 6,000 gallons per day in summer and 2,000 gallons per day in winter. The machinery consists of five 80 quart, and one 40 quart Miller freezers; two 500 gallon Elyria glass-lined pasteurizers; one 400 gallon Manton-Gavlin homogenizer; one 500 gallon Miller cooler; and four 1,000 gallon glass-lined Elyria holding vats. In addition to the above equipment there are about 350 feet of connecting piping.

After each day's run, the piping and machinery were first rinsed with cold water and then with boiling water. Live steam was then run through the piping. It was then taken down and scoured with a satisfactory commercial cleaning powder. When they were ready to use it the piping was reassembled and rinsed with hot water and then treated with flowing steam. In this way it was possible to keep the contamination down to a minimum.

PLAN OF WORK

Thoroughly mixed samples of cream, condensed milk, and gelatin were taken from the materials going into each batch and plated on agar. This was done to find out the bacterial content of the raw product. The above constituents contribute the greatest number of bacteria to ice cream as previous workers have shown. (Stiles and Pennington (5), Gordon (6) and Hammer (2).) The mix made from these materials was then prepared in the regular way and given a number which is called the "batch" number. Samples were again taken of the mix just before pasteurization.

The mix was then pasteurized at 65.6° C (150° F) for 30 minutes and samples taken and plated. The mix then passed through the homogenizer under pressure ranging from 2,500 to 3,000 pounds. Samples were taken again at the end of this operation. From the homogenizer the mix passed to the cooler where it was cooled to 10° C (50° F). Samples were taken before and after cooling. The mix then passed to the holding vat where it was held for 24 hours at 2° C (35.6° F) for aging. Samples were taken at the beginning and at the end of the aging period. From the holding vats the mix went to freezers and samples were taken just before it was frozen and again as it was leaving the freezers in a semi-solid state.

It was our original plan to follow the ice cream through at least four weeks of storage but this was abandoned after several of our sample containers had been shipped out by mistake. However, considerable previous work by Stiles and Pennington (5), Gordon (6), Hammer (2), Esten and Mason (7) and Ellenberger (8) has covered this phase of the problem quite completely. The samples collected according to the above scheme were taken to the laboratory and plated immediately on plain agar and incubated for 48 hours at 37° C.

It will be seen that our plan of work starts with the raw materials going into the mix and then follows the mix through each successive operation as it goes through the plant and as it comes out a finished product, samples being taken before and after each operation and plated immediately to determine the influence of each particular operation on the bacterial content of the mix. In this way it was hoped to throw some light on the influence of each of the various operations on the number of bacteria as determined by the plate method.

METHODS

All samples were collected with sterile pipettes and plated immediately. Samples of the mix up to the time it was frozen were easily collected and plated. After the mix was frozen a slightly different procedure was followed. The method used by Ayers and Johnson (9) with slight modifications was used for obtaining the number of bacteria in the ice cream after it had been frozen and placed in cans. The top of the can was rinsed with water, the cover removed and the top inch or so of ice cream taken off with a sterile spoon. A sterile butter trier was then pushed to the bottom of the can and the solid core placed in a sterile flask. Three cores from each can were taken in this way from different parts of the can and placed in the flask. The samples of ice cream collected from the freezers were caught in sterile wide-mouthed bottles as it flowed from the freezer. A gallon or so was always allowed to run out before the sample was collected.

The samples were then placed in a water bath at 40° C (104° F) for 15 minutes or until melted. After melting they were shaken 30 times to get rid of the air which is very abundant in frozen ice cream. In all cases suitable dilutions were made using 90 cc. and 99 cc. respectively, of sterile physiological salt solution. The dilution flasks were shaken 25 times and 1 cc. was plated from each dilution desired.

The agar used in plating was Standard nutrient agar made according to the method recommended by the American Public Health Association (10). The pipettes used were standard bacteriological pipettes graduated to deliver a calibrated amount between two marks, thus avoiding any error due to blowing. All calculations are based upon cubic centimeters of ice cream and not on grams except for gelatin. In the case of gelatin, one gram was weighed on a sterile filter paper and the contents poured into 99 c. c. of sterile physiological salt solution. Suitable dilutions were made from this and bacteria calculated per gram. All plates were made in duplicate and incubated at 37° C for 48 hours. The counts represent an average of the two plates containing from 30 to 300 colonies or those coming the nearest to 300. Determinations were made only on vanilla ice cream.

THE RAW PRODUCTS

The raw products that went into the mix were analyzed for the number of bacteria per c. c. or gram in the case of gelatin.

The data are presented in Table 1.

Table I.—Bacterial Colonies per c. c. of Raw Products. (No Other Colonies Except Bact.).

Batch No.	A Cream.	B Cream.	Condensed Milk.	Gelatin.*
20	50,000	1,800,000	8,000	2,000,000
22	5,980,000	300,000	250,000	2,000,000
23	5,040,000	800,000	220,000	2,000,000
24	460,000	300,000	80,000	2,000,000
25	2,500,000	....	1,300,000	1,970,000
26	210,000	500,000	2,300,000	1,970,000
27	10,000	1,300,000	7,500,000	1,970,000
35	270,000	....	20,000	1,970,000
37	300,000	2,100,000	220,000	1,120,000
54	30,000	8,000,000	300,000	1,120,000
57	6,000,000	....	50,000	1,120,000
217A	280,000	2,000,000	130,000	1,120,000
219	3,780,000	650,000	220,000	1,120,000
220	640,000	530,000	400,000	1,120,000
222	750,000	1,260,000	380,000	1,120,000
223	2,260,000	270,000	190,000	850,000
226	170,000	2,500,000	120,000	850,000
228	4,200,000	1,630,000	50,000	850,000
229	220,000	880,000	1,000,000	850,000
231	3,850,000	200,000	30,000	850,000
1	3,100,000	20,000	30,000	850,000
2	930,000	260,000	350,000	850,000
3	3,500,000	2,600,000	30,000	850,000
4	7,500,000	250,000	30,000	850,000
5	2,900,000	250,000	130,000	2,900,000
6	140,000	50,000	90,000	2,900,000
7	100,000	1,250,000	70,000	2,900,000
8	50,000	200,000	20,000	2,900,000
9	350,000	200,000	20,000	2,900,000
10	50,000	2,000,000	140,000	2,900,000
11	150,000	50,000	10,000	2,900,000
12	130,000	50,000	1,250,000	2,900,000
13	220,000	10,000	1,250,000	2,800,000
14	400,000	220,000	1,250,000	2,800,000
15	13,000	70,000	10,000	2,800,000
16	4,400,000	13,000	60,000	2,800,000
17	300,000	140,000	210,000	2,800,000
18	390,000	310,000	240,000	2,800,000
19	650,000	60,000	240,000	2,800,000
120	50,000	430,000	1,900,000	4,000,000
121	230,000	50,000	1,900,000	4,000,000
122	70,000	280,000	1,900,000	4,000,000
123	50,000	150,000	170,000	4,000,000
124	20,000	100,000	220,000	4,000,000
125	750,000	160,000	1,100,000	4,000,000
126	1,000,000	300,000	1,100,000	4,000,000
127	3,780,000	430,000	50,000	4,000,000
128	1,950,000	430,000	30,000	4,000,000

*Counts on gelatin were made only when a new lot was used and are based on number per gram.

The cream used in this plant was pasteurized cream. The company bought it from two different sources in order to obtain a sufficient supply. This explains the two columns for cream in Table I. The butter fat ranged from 20 per cent to 45 per cent. The cream was usually used from one to four days after pasteurization. The bacterial count varied from 10,000 to 8,000,000 per cubic centimeter with an average of 1,100,000 per cubic centimeter.

The condensed milk used was also of two kinds. The whole condensed milk contained about 8 per cent butter fat and 30 per cent total solids. The condensed skim milk contained about 27 per cent total solids. The bacterial count ranged from 8,000 to 7,500,000 bacteria per cubic centimeter with an average of 600,000 per cubic centimeter.

Gelatin was bought in large quantities and each lot was very constant in the number of bacteria present. For this reason samples were collected from each shipment and thoroughly mixed and a bacterial count made. This count was used until a new shipment was received. Enough gelatin was ordered each time to last from four to eight weeks. The bacterial count ranged from 850,000 to 4,000,000 per cubic centimeter with an average of 2,500,000 per cubic centimeter. The gelatin was added just before pasteurization in the powdered form.

THE INFLUENCE OF PASTEURIZATION UPON THE BACTERIAL CONTENT OF THE ICE CREAM MIX

The next step in the manufacturing process is the mixing of the raw products and standardization of the mix. The mix is then pasteurized. The raw prodcts as was shown in Table I contained large numbers of bacteria. When the products were mixed together they still contained large numbers as is shown in Table II. Pasteurization as carried out at this factory was at 65.6° C (150° F) for 30 minutes. The type of pasteurizer used was a 500 gallon glass-lined Elyria type.

The data showing the influence of pasteurization of the mix on the bacterial content are presented in Table II. The percentage decreases in the number of bacteria due to pasteurization varied from 94.5 per cent to 99.9 per cent. The average per cent decrease being 98.97. The above data should leave no doubt in the mind of any one as to the value of pasteurization as a means of reducing the number of bacteria in the ice cream mix.

Table II.—Bacterial Content of Mix Before and After Pasteurization

Batch No.	Bacterial count of mix before pasteurization. No. of bacteria.	Bacterial count of mix after pasteurization. No. of bacteria.	Per cent decrease.
20	200,000	3,500	98.3
22	1,800,000	2,000	99.9
23	1,200,000	8,000	99.3
24	1,300,000	45,000	96.5
25	1,500,000	50,000	98.7
26	5,200,000	22,000	99.6
27	950,000	25,000	97.4
35	300,000	10,000	96.7
37	1,350,000	21,000	98.4
54	1,250,000	15,000	98.8
57	2,500,000	11,000	99.6
217A	1,610,000	4,000	99.7
219	1,090,000	2,500	99.8
220	1,190,000	4,000	99.7
222	150,000	1,000	99.3
223	100,000	5,500	94.5
226	1,300,000	12,000	99.1
228	4,500,000	9,000	99.8
229	3,300,000	8,500	99.7
231	340,000	1,500	99.6
1	1,790,000	2,000	99.9
2	960,000	2,000	99.8
3	2,000,000	....	....
4	1,250,000	2,000	99.8
5	470,000	2,000	99.6
6	300,000	2,000	99.3
7	820,000	3,000	99.6
8	60,000	1,000	98.3
9	240,000	1,000	99.5
10	180,000	1,500	99.2
11	50,000	500	99.0
12	680,000	2,100	99.7
13	150,000	200	99.9
14	480,000	2,500	99.5
15	200,000	400	99.8
16	210,000	400	99.8
17	420,000	200	99.9
18	900,000	....	....
19	250,000	1,100	99.6
120	500,000	500	99.9
121	280,000	4,100	98.5
122	570,000	2,200	99.6
123	150,000	1,100	99.3
124	650,000	1,600	99.7
125	370,000	500	99.9
126	650,000	18,100	97.2
127	1,760,000	200	99.9
128	1,200,000	700	99.9

THE INFLUENCE OF HOMOGENIZING UPON THE BACTERIAL CONTENT OF THE ICE CREAM MIX

After the mix had been pasteurized at 65.6° C (150° F) for 30 minutes it was immediately started for the homogenizer where it was homogenized under from 2,500 to 3,000 pounds pressure. The temperature of the mix as it passed through the homogenizer was slightly less (between 60° and 65° C.) than that at which it was pasteurized. The results are given in Table III.

An analysis of Table III shows that in 74.0 per cent of the cases there was an increase in the number of bacterial colonies ranging from 1,400 per cent to 5.9 per cent after the pasteurized mix had passed through the homogenizer. This increase may be due to two causes. The first cause may be contamination from the homogenizer. Hammer and Sanders (4)

Table III.—Bacterial Content of the Mix Before and After Homogenizing

Batch No.	Bacterial count of mix after pasteurizing and before homogenizing.	Bacterial count after homogenizing and before cooling.	Per cent increase.	Per cent decrease.
20	3,500	14,000	300.0	...
22	2,000	2,000	No change	
23	8,000	10,000	25.0	...
24	45,000	60,000	33.3	...
25	50,000	63,000	26.0	...
26	22,000	20,000	...	9.09
27	25,000	25,000	No change	...
35	10,000	22,000	120.0	...
37	21,000	48,000	128.6	...
54	15,000	42,000	180.0	...
57	11,000	19,000	72.7	...
217A	4,000	7,000	75.0	...
219	2,500	6,000	140.0	...
220	4,000	4,000	No change	...
222	1,000	2,000	100.0	...
223	5,500	7,000	27.3	...
226	12,000	10,000	...	16.66
228	9,000	15,000	66.6	...
229	8,500	9,000	5.9	...
231	1,500	2,000	33.3	...
1	2,000	7,000	250.0	...
2	2,000	3,000	50.0	...
4	2,000	4,000	100.0	...
5	2,000	1,000	...	50.0
6	2,000	30,000	1,400.0	...
7	3,000	3,000	No change	...
8	1,000	1,000	No change	...
9	1,000	3,000	200.0	...
10	1,500	2,000	33.3	...
11	500	1,500	200.0	...
12	2,100	2,700	28.6	...
13	200	300	50.0	...
14	2,500	2,500	No change	...
15	400	800	100.0	...
16	400	750	87.5	...
17	200	2,200	1,000.0	...
19	1,100	1,250	13.6	...
120	500	500	No change	...
121	4,100	4,700	14.6	...
122	2,200	2,000	...	9.09
123	1,100	2,000	81.8	...
124	1,600	2,500	56.3	...
125	500	700	40.0	...
126	18,100	2,500	...	86.188
127	200	450	125.0	...
128	700	1,400	100.0	...

have shown that the homogenizer may be a source of contamination especially for the first material passing through. They ran the ice cream mix through the homogenizer both with and without pressure and found that without pressure there was an increase in all cases. They concluded that the increase was due to contamination from the homogenizer because in all cases the figures obtained were on the first material passing through the homogenizer. As the process was continued the presumption was that the contamination would become less due to the washing effect.

The second cause of an increase in the bacterial count may be the breaking up of clumps of bacteria as the mix passes through the homogenizer under pressure. The increase in this case would be an apparent rather than a real increase and should be taken into consideration in formulating a bacterial standard for ice cream.

The increases noted in Table III are presumably due to the second cause because the samples were obtained in a majority of the cases in the middle of the forenoon or shortly after noon to allow sufficient time to analyze. The machinery had been in operation for some time so that the contamination from the machine itself would be lessened.

In 10.8 per cent of the samples there was a decrease and in 15.2 per cent no change in the number of bacteria while in 74 per cent there was an increase. The reason for so many samples showing an increase may also be due to the high pressure at which homogeninzing is done at this plant. The pressure generally used is about 2,000 pounds.

THE INFLUENCE OF COOLING THE ICE CREAM MIX UPON THE BACTERIAL CONTENT

After the mix had passed through the homogenizer (at about 60° C, 140° F) it was immediately pumped to the cooler where it was cooled to 10° C (50° F). A study was made of the influence of cooling the mix from 60° C to 10° C on the bacterial content. The data are presented in Table IV.

Table IV.—Showing Bacterial Counts Before and After Cooling of Mix

Batch No.	Bacterial count of mix before cooling.	Bacterial count of mix after cooling.	Per cent increase.	Per cent decrease.
20	14,000	13,000		7.14
22	2,000	2,500	25.0	
23	10,000	12,000	20.0	
24	60,000	60,000	No change	
25	63,000	65,000	3.17	
26	20,000	20,000	No change	
27	25,000	25,000	No change	20.00
35	22,000	33,000	50.0	
37	48,000	20,000		58.33
54	42,000	40,000		4.76
57	19,000	35,000	84.21	
217A	7,000	13,000	85.71	
219	6,000	7,000	16.66	
220	4,000	7,000	75.00	
222	2,000	4,000	100.00	
223	7,000	7,500	7.14	
226	10,000	10,000	No change	
228	15,000	20,000	33.33	
229	9,000	8,000		11.11
231	2,000	4,000	100.00	
1	7,000	7,000	No change	
2	3,000	2,000		33.33
4	4,000	2,000		100.00
5	1,000	1,000	No change	
6	30,000	12,000		60.00
7	3,000	5,000	66.67	
8	1,000	1,000	No change	
9	3,000	2,000		33.33
10	2,000	2,000	No change	
11	1,500	7,500	400.00	
12	2,700	2,500		7.41
13	300	300	No change	
14	2,500	2,800	12.00	
15	800	900	12.50	
16	750	500		33.33
17	2,200	2,400	9.09	
19	1,250	1,300	4.00	
120	500	700	40.00	
121	4,700	1,500		68.08
122	2,000	2,400	20.50	
123	2,000	2,100	5.00	
124	2,500	2,300		8.00
125	700	700	No change	
126	2,500	3,500	40.00	
127	450	500	11.11	
128	1,400	1,600	14.29	

The object of studying the influence of cooling upon the number of bacteria was to determine what influence a change from a high temperature 60° C (140° F) to a lower temperature 10° C (50° F) would have upon the number of bacteria in the mix. It is a well known fact that all dairy products must be cooled to temperatures below normal so as to keep bacterial activity at a minimum. Aside from this what are the advantages of cooling? Does cooling *per se* kill bacteria?

In 52.17 per cent of the samples there was an increase in the number of bacteria after cooling. The increase was from 3.17 per cent to as high as 400.00 per cent with an average of 51.45 per cent. In 26.08 per cent of the samples there was a decrease ranging from 4.76 per cent to as high as 100.00 per cent with an average of 27.29 per cent while 21.75 per cent of the samples showed no change.

These data would indicate that the process of cooling the mix from a high temperature to a lower one does not necessarily reduce the number of bacteria as determined by the plate method. Abundant data, Roadhouse (13), Marshall (11), Reed and Reynolds (12), are available, however, to show that cooling is necessary to reduce bacterial activity to a minimum.

THE INFLUENCE OF AGING ON THE BACTERIAL CONTENT OF THE ICE CREAM MIX

After the ice cream mix had been cooled to 10° C (50° F) it was run into the holding tanks where it was held for 24 hours at about 2° C (35.6° F) for aging. The variation in the temperature was slight, not over 2° or 3° C.

Aging, as every ice cream maker knows, is a very desirable step in the process of making ice cream since it influences the viscosity and this in turn, as Mortensen (14) has shown, influences the body and the yield of the finished product. It is, therefore, interesting to study the influence of aging upon the number of bacteria in the mix. The influence of this process on the bacterial count is shown in Table V.

Eighteen or 47.36 per cent of the samples in Table V showed an increase ranging from 4.35 per cent to as high as 409.09 per cent with an average increase of 103.00 percent. The average increase would indicate that the multiplication was considerable, especially since only three samples show low increases within the limits of experimental error. In 42.10 per cent of the cases there was a decrease in bacterial count ranging from 4.54 per cent to as high as 81.81 per cent with an average decrease of 26.98 per cent while 10.52 per cent of the samples showed no change.

The temperature at which the aging was done, 2° C (35.6° F), would have a tendency to keep down the number of certain bacteria as it is a well known fact that many bacteria found in ice cream grow best only at higher temperatures. If these particular bacteria predominated in the mix, we would expect to have a decrease or at best no increase during the period of aging. That there was no increase would indicate that these bacteria were either dormant or slowly dying. On the other hand those samples in which there was an increase would indicate that there were present certain types that were capable of multiplying at low tem-

Table V.—Showing Bacterial Count of Mix Before and After Aging

Batch No.	Bacterial count of mix before aging.	Bacterial count of mix after aging.	Per cent increase.	Per cent decrease.
20	7,000	5,000	...	28.57
22	30,000	34,000	13.33	...
23	65,000	35,000	...	46.15
24	63,000	60,000	...	4.76
25	80,000	50,000	...	37.50
26	25,000	20,000	...	20.00
27	110,000	20,000	...	81.81
35	35,000	32,000	...	8.57
37	72,000	60,000	...	16.66
54	40,000	25,000	...	37.50
57	25,000	16,000	...	36.00
217A	56,000	105,000	87.50	...
219	20,000	20,000	No change	...
220	12,000	...	...	...
222	5,000	12,500	150.00	...
223	12,000	8,000	...	33.33
226	22,000	21,000	...	4.54
228	24,000	48,000	100.00	...
229	14,000	17,000	21.43	...
231	11,000	18,000	63.64	...
1	7,500	...	...	...
2	...	3,000	...	...
3	...	47,000	...	...
4	10,000	20,000	100.00	...
5	3,000	9,000	200.00	...
6	...	8,000	...	...
7	18,000	22,000	22.22	...
8	8,000	9,000	12.50	...
9	13,000	13,000	No change	...
10	7,000	4,000	...	42.86
11	11,500	17,000	47.82	...
12	6,400	...	...	...
13	14,000	13,000	...	7.14
14	2,300	2,700	17.26	...
15	1,700	6,500	282.35	...
16	2,500	2,500	No change	...
17	4,700	...	...	...
18	2,700	2,300	...	14.81
19	2,600	...	...	...
120	2,600	2,300	...	11.53
121	11,500	12,000	4.35	...
122	2,900	...	...	...
123	4,200	4,500	7.14	...
124	4,500	4,500	No change	...
125	2,700	6,200	129.63	...
126	7,000	13,000	85.71	...
127	1,100	5,600	409.09	...
128	3,800	...	...	...

peratures. That the bacteria were not dying at a very rapid rate is evidenced by the fact that the average percentage decrease was low (26.98 per cent.) Pennington and Walter (12), in a study of commercial ice cream, found that 80 per cent of the samples studied contained streptococci which actually showed a greater relative rate of growth at the temperature of the refrigerator (12° C) than at higher temperatures. In addition to the above group there are, according to Marshall (9), certain species especially some of the spore-bearing non-acid formers which will grow quite rapidly at temperatures below 10° C. These are especially undesirable species, in that they are capable of splitting proteins with the production of bitter and astringent flavors and of producing poisonous split protein by-products.

THE INFLUENCE OF FREEZING ON THE BACTERIAL CONTENT OF THE ICE CREAM MIX

After the ice cream mix has aged 24 hours it was then frozen in 80 quart Miller freezers. The temperature of the brine at which the mix is frozen ranges from —15.5° C (4° F) to —12.2° C (10° F) with an average of —14° C (7° F). The samples were collected just as the material was leaving the freezers. The influence of this process is given in Table VI.

Table VI.—Showing Bacterial Count Before and After Freezing

Batch No.	Bacterial count of mix before freezing.	Bacterial count of mix after freezing.	Per cent increase.	Per cent decrease.
20	5,000	18,000	260.00	
22	34,000	34,000	No change	
23	35,000	35,000	No change	
24	60,000	75,000	25.00	
25	50,000	50,000	No change	
26	20,000	22,000	10.00	
27	20,000	20,000	No change	
35	32,000	33,000	3.12	
37	60,000	27,000		55.00
54	25,000	62,000	148.00	
57	16,000	16,000	No change	
217A	105,000	106,000	00.95	
219	20,000	28,000	40.00	
222	12,500	11,000		12.00
223	8,000	11,500	43.75	
226	21,000	19,000		9.52
228	48,000	53,000	10.42	
229	17,000	14,000		17.64
231	18,000	15,000		16.67
2	3,000	2,000		33.33
3	47,000	38,000		19.15
4	20,000	22,000	10.00	
5	9,000	7,000		22.22
6	8,000	6,000		25.00
7	22,000	26,000	18.18	
8	9,000	16,000	77.77	
9	13,000	13,000	No change	
10	4,000	9,000	125.00	
11	11,000	14,500	31.82	
13	13,000	8,600		33.85
14	2,700	2,700	No change	
15	6,500	5,000		23.08
16	2,500	2,600	4.00	
18	2,300	2,500	8.70	
120	2,300	2,600	13.04	
121	12,000	9,800		18.33
123	4,500	2,700		40.00
124	4,500	5,600	24.44	
125	6,200	2,500		59.68
126	13,000	12,500		3.85
127	5,600	7,200	28.57	

The results in Table VI show that in 46.34 per cent of the samples there was an increase ranging from 0.95 per cent to 260.00 per cent with an average increase of 46.47 per cent. In 36.58 per cent of the samples there was a decrease ranging from 3.85 per cent to 59.68 per cent with an average of 25.95 per cent decrease while in 17.07 per cent of the samples there was no change. The increase in the number of colonies is no doubt due largely to the breaking up of clumps of bacteria. Many clumps which ordinarily would produce one colony are presumably broken up into several clumps or single cells each of which may produce a colony. The increase as a result of freezing, aside from that due to the contamination from the freezer, which probably is practically negligible after the first few batches, is more apparent than real. In the case of homogenizing there is a greater increase (74 per cent) in bacteria as determined by the plate count which no doubt is due to the mechanical process, as in the case of freezing; but with the higher temperature of the former process there should be considered the rather remote possibility of bacteria multiplying even in so short a time. In the process of freezing, however, the temperatures to which the ice cream mix is subjected (7° F) would exclude the possibility of any great increase in the actual number of bacteria. In fact the opposite should be true. This would account for the decrease noted in 36.58 per cent of the samples. In other words if the mix as it entered the freezer contained few or no clumps then instead of expecting an increase due to their breaking up, there should be a decrease due to the unfavorable temperature of the freezer.

It will be noted that in no case was the decrease very great, and the average is low as compared with the average of the increase. This is about what would be expected because the change of temperature from aging (35° F) to freezing (7° F) is not very great, being about (28° F). The apparent increase on the other hand would depend quite largely on the size and number of clumps present and these in turn would depend to a certain extent upon the previous treatment of the mix, such as length of time it has aged, pressure used in homogenizing, whether pasteurized or not and if so at what temperatures.

THE INFLUENCE OF STORAGE ON THE BACTERIAL CONTENT OF ICE CREAM

After the ice cream mix had been frozen it was put in five-gallon cans and stored in the refrigerator at an average of —20.5° C (—5° F). The temperature varies not more than 5° F from this average. In the morning before work it reaches as low as —10° F but during the day while many are using the refrigerator it rises to as high as 0° F. The results of storage on the bacterial count are shown in Table VII.

In Table VII are tabulated the results of storing ice cream over various periods. A count was taken of the ice cream when it was first put into the sterile can. It was the original plan to take samples at the end of one day, one week, two, three, and four weeks. It was found impracticable to carry this out so the data are not as complete as they should be. The results show that for the first day's storage there is a decrease in the majority of cases. In eight out of twelve samples, or in 66.66 per cent of the cases, there is a decrease; and in three out of twelve, or in twenty-five per cent of the cases, there is an increase; while in one case there is no change. The decrease in counts ranged from 72.22 per cent to 9.09 per cent, with an average of 41.89 per cent. The increase in counts ranged from 2.94 to 125 per cent, with an average of 48.81 per cent. At the end of one week 6 out of 7 samples, or 85.71 per cent of the samples, showed a decrease ranging from 9.09 per cent to 33.33 per cent, with an average of 23.90 per cent decrease, and one sample showed no change over the one

Table VII.—Showing Bacterial Counts at Different Intervals of Storage

Batch No.	Before storage.	One day of storage.	Per cent increase or decrease.	One week of storage.	Per cent increase or decrease.	Two weeks of storage.	Per cent increase or decrease.	Three weeks of storage.	Per cent increase or decrease.
20	18,000	5,000	−72.22	5,000	0	4,000	−20.0	6,000	50.00
22	34,000	35,000	2.94	24,000	−31.43	26,000	8.33	16,000	−38.46
23	35,000	27,000	−22.85	18,000	−33.33	30,000	66.67		
24	75,000	22,000	−70.66	15,000	−31.82	6,000	−60.00		
25	50,000	45,000	−10.00	40,000	−11.11	35,000	−12.50		
26	22,000	22,000	0	20,000	−9.09				
27	20,000	45,000	125.00						
35	33,000	30,000	−9.09	22,000	−26.67	21,000	−4.55		
37	27,000	32,000	18.52						
51	62,000	22,000	−64.50						
57	16,000	8,000	−50.00						
217	106,000	68,000	−35.85						

day period, but a decrease over the initial number. At the end of two weeks 4 out of 6 samples showed a decrease over the one week period while 2 showed an increase over the one week period but a decrease over the one day period. Only two samples were analyzed at the end of the three week period. One showed an increase over the two week period but a decrease over the initial count while the other showed a decrease over both the two week period and the initial count.

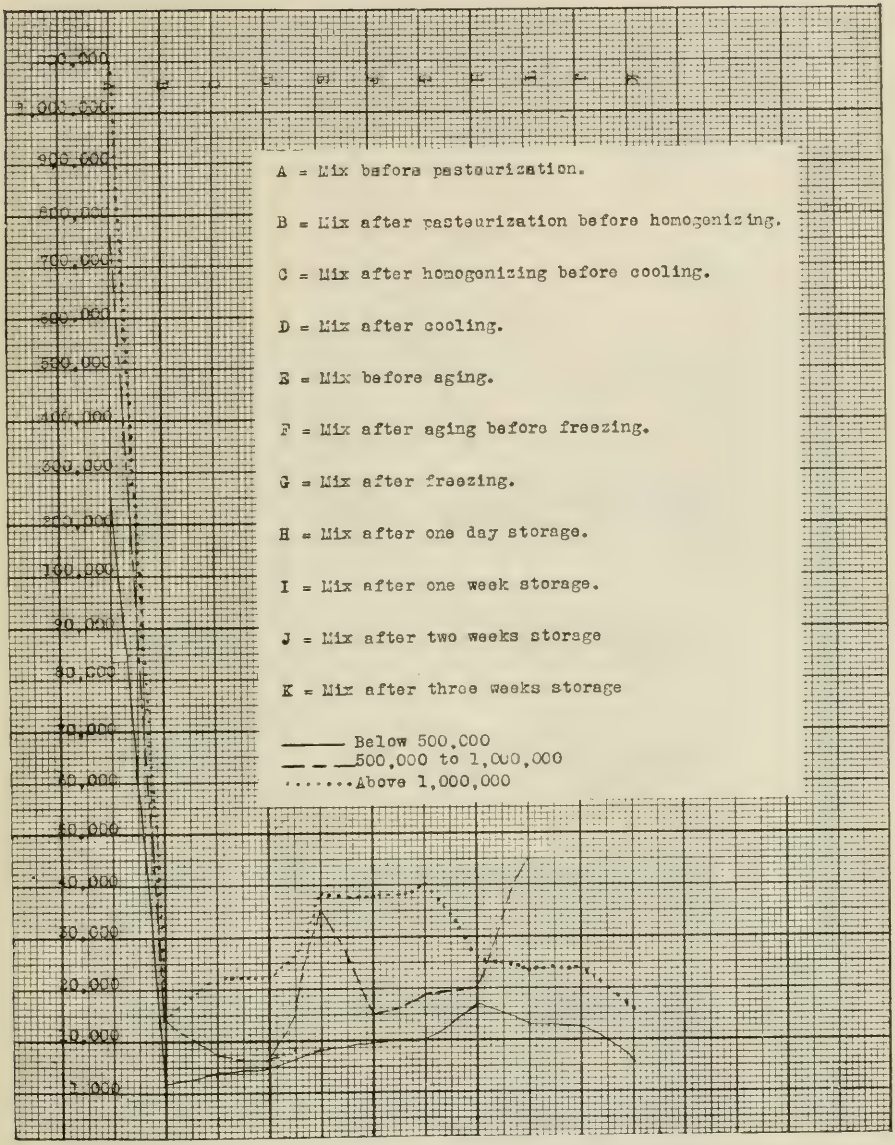
The general conclusions that one is forced to draw from the data presented in Table VII are to the effect that the numbers of bacteria decrease during the storage of ice cream. There may be fluctuations in individual samples during the process of storage, but the number of bacteria in the end is less than at the beginning. Hammer (2) made determinations on twelve samples that had been held from periods ranging from 10 to 44 days and reached this conclusion: "From these results it seems safe to conclude that during the period of storage of ice cream there is no increase in the number of bacteria capable of developing on agar." Esten and Mason (7) held several samples of ice cream for about a month and concluded that there is no marked increase or decrease in the number of bacteria. Ellenberger (8) who went into this matter quite extensively reached the following conclusion: "There is no radical change in the total number of bacteria in ice cream during storage. There seems, however, to be a tendency towards a slight decrease during the first two to four days, with a more noticeable increase and a corresponding decrease again between the fourth and twenty-first day, after which time there is a very gradual falling off in numbers."

GENERAL DISCUSSION OF RESULTS

As was stated in the beginning our plan was to start with the mix and trace it through each process in the factory until it came out the finished product. The results of the influence of each process on the bacterial count are shown in Tables VIIIa, VIIIb and VIIIc. The data on the bacterial counts of the mix were divided into three parts. Those data tabulated in Table VIIIa represent the bacterial counts of those batches whose bacterial count is below 500,000 bacteria per c.c. In Table VIIIb are tabulated batches whose bacterial counts are between 500,000 and 999,999 and in Table VIIIc batches whose bacterial counts are over 1,000,000 per c.c.

The counts were then averaged and the averages plotted in the form of a graph. The number of bacteria per c.c. are represented as ordinates, while the abscissae represent the manufacturing operations. The straight line curve represents the results from Table VIIIa, the broken line curve the results from Table VIIIb, and the dotted line curve the results of Table VIIIc.

A study of this graph shows some very interesting things. It is interesting to note that all three take the same general direction. The broken line graph is very irregular. This is due to the fact that few samples fell in this class so that the averages are erratic, which in turn make the graph irregular. The other two lines, however, show the same general trend upward. The course that these graphs take indicates that each



manufacturing operation has a tendency to increase the bacterial count of the mix. From the time the mix enters the factory until it is placed in the cooler, there is the general tendency to increase bacterial counts. The only process that is an exception to this is pasteurization. As was pointed out in some cases the increases may be only apparent. In those processes where there is mechanical agitation as in homogenizing and freezing, the increase is more apt to be apparent than real.

Table VIIIa.—Showing Bacterial Count According to Different Operations With Averages for Counts Below 500,000

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
	200,000	3,500	14,000	13,000	7,000	5,000	18,000	5,000	5,000	4,000	6,000
	300,000	10,000	22,000	33,000	35,000	32,000	33,000	30,000	22,000	21,000	....
	150,000	1,000	2,000	4,000	5,000	12,500	11,000	....	....	....	....
	100,000	5,500	7,000	7,500	12,000	8,000	11,500	....	....	....	....
	330,000	8,500	9,000	8,000	14,000	17,000	14,000	....	....	....	....
	340,000	1,500	2,000	4,000	11,000	18,000	15,000	....	....	....	....
	470,000	2,000	1,000	1,000	3,000	9,000	7,000	....	....	....	....
	240,000	1,000	3,000	2,000	13,000	13,000	13,000	....	....	....	....
	60,000	1,000	1,000	1,000	8,000	9,000	16,000	....	....	....	....
	50,000	500	1,500	7,500	11,500	11,000	14,500	....	....	....	....
	500,000	500	500	700	2,600	2,300	2,600	....	....	....	....
	150,000	200	300	300	14,000	13,000	8,690	....	....	....	....
	480,000	2,500	2,500	2,800	2,300	2,700	2,700	....	....	....	....
	200,000	400	800	900	1,700	6,500	5,000	....	....	....	....
	210,000	400	750	500	2,500	2,500	2,600	....	....	....	....
	280,000	4,100	4,700	1,500	11,500	12,000	9,800	....	....	....	....
	150,000	1,100	2,000	2,100	4,200	4,500	2,700	....	....	....	....
	370,000	500	700	700	2,700	6,200	2,500	....	....	....	....
	190,000	1,500	2,000	2,000	7,000	4,000	9,000	....	....	....	....
Aver...	250,000	2,400	4,200	5,000	8,900	9,800	10,000	17,000	13,000	12,000	6,000

Table VIIIb.—For Counts Between 500,000 and 999,999

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
	950,000	25,000	25,000	20,000	110,000	20,000	20,000	20,000	45,000	....	....
	820,000	3,000	3,000	5,000	18,000	22,000	26,000	....	....	....	....
	650,000	1,600	2,500	2,300	4,500	4,500	5,600	....	....	....	....
	650,000	18,100	2,500	3,500	7,000	13,000	12,500	....	....	....	....
Aver...	760,000	14,000	8,200	7,700	35,000	15,000	19,000	20,000	45,000	....	....

Table VIIIc.—For Counts Of 1,000,000 and Above

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
1,800,000	2,000	2,000	2,500	30,000	34,000	34,000	35,000	24,000	26,000	16,000
1,200,000	8,000	10,000	12,000	65,000	35,000	35,000	27,000	18,000	30,000	....
1,300,000	45,000	60,000	60,000	63,000	60,000	75,000	22,000	15,000	6,000	....
1,500,000	50,000	63,000	65,000	80,000	50,000	50,000	45,000	40,000	35,000	....
5,200,000	22,000	20,000	20,000	25,000	20,000	22,000	22,000	20,000	....	....
1,350,000	21,000	48,000	20,000	72,000	60,000	27,000	32,000	....	....	....
1,250,000	15,000	42,000	40,000	40,000	25,000	62,000	12,000	....	....	....
2,500,000	11,000	19,000	35,000	25,000	16,000	16,000	8,000	....	....	....
1,600,000	4,000	7,000	13,000	56,000	105,000	106,000	....	....	....	....
1,000,000	2,500	6,000	7,000	20,000	20,000	28,000	....	....	....	....
1,300,000	12,000	10,000	10,000	22,000	21,000	19,000	....	....	....	....
4,500,000	9,000	15,000	20,000	24,000	48,000	53,000	....	....	....	....
1,200,000	2,000	4,000	2,000	10,000	20,000	22,000	....	....	....	....
1,760,000	200	450	500	1,100	5,600	7,200	....	....	....	....
Aver. 2,000,000	14,500	22,000	22,000	38,000	37,000	40,000	26,000	23,000	24,000	16,000

In Tables VIIIa, VIIIb and VIIIc
A = Mix before pasteurization.
B = Mix after pasteurization before homogenizing.
C = Mix after homogenizing before cooling.
D = Mix after cooling.
E = Mix after aging.
F = Mix after aging before freezing.
G = Mix after freezing.
H = Mix after one day storage.
I = Mix after one week storage.
J = Mix after two weeks storage.
K = Mix after three weeks storage.

Column G of Tables VIIIa, VIIIb, and VIIIc represents the finished product, the bacteria per c.c. as the mix had been frozen and was flowing away from the freezer. By referring to Column G it will be noted that the highest number of bacteria per c.c. is 106,000 and the lowest is 2,500 per c.c. This justifies the conclusion that an ice cream of low bacterial content can be made in a sanitary plant from raw materials of high germ content when resort is made to pasteurization and other sanitary measures.

CONCLUSIONS

1. This work confirms the conclusions of other investigators that,—Cream, condensed milk and gelatin, the principal raw products going into the ice cream mix, contain many bacteria.
2. Pasteurizing the ice cream mix at 65.6° C (150° F) for 30 minutes lowers the plate count, from 94.5 per cent to 99.9 per cent, with an average efficiency of 98.97 per cent as determined by the plate method described.
3. Homogenizing the ice cream increases the number of bacteria as determined by the plate method. The increase may be apparent rather than real. No attempt was made to determine whether it was apparent or real.
4. Cooling from approximately 60° C. to 10° C. is not effective in killing all the bacteria since a slight majority of the samples showed an increase.
5. Aging at 2° C for 24 hours has a tendency to increase the plate count as a majority of samples shows.
6. Freezing with the brine at an average of —14° C. has a tendency to increase the number of bacteria in ice cream. The recorded increase may be apparent rather than real.
7. Storage of ice cream at an average of —20.5° C from one day to three weeks decreases the plate count in the majority of cases. There may be variations in individual samples.
8. After the mix is pasteurized every subsequent operation has the general tendency to increase the plate count.
9. It is possible to make vanilla ice cream on a commercial scale with a low plate count.

REFERENCES

1. Pennington and Walter, Bacteriological Study of Commercial Ice Cream. N. Y. Med. Jr. Vol. LXXXVI, p. 1013.

2. Hammer (1912) Bacteria and Ice Cream. Bul. 134 Iowa Agr. Exp. Station.

3. Hammer and Goss, (1917) Bacteria in Ice Cream II. Bul. 174, Iowa Agr. Exp. Station.

4. Hammer and Sanders (1919) A Bacteriological Study of the Method of Pasteurizing and Homogenizing the Ice Cream Mix. Bul. 186, Iowa Agr. Exp. Station.

5. Stiles and Pennington (1909) Bacteriological Investigations of Ice Cream in the District of Columbia. Bul. 56, pp. 263-269. U. S. Hygienic Lab., Public Health and Marine Hospital Service.

6. Gordon (1914) Report on Ice Cream Examinations Outlined in Washington Hearing of Ice Cream Manufacturers. The National Association of Ice Cream Manufacturers.

7. Esten and Mason (1915). The Bacteria in Ice Cream. Bul. 83, Conn. (Storrs) Agr. Exp. Station.

8. Ellenberger (1919). A Study of Bacteria in Ice Cream During Storage. Memoir 18. Cornell Agr. Exp. Station.

9. Ayers and Johnson (1917). The Determination of Bacteria in Ice Cream. Bul. 563 U. S. Dept. of Agr.

10. A. P. H. A. (1921). Standard Methods for the Bacteriological Examination of Milk. Third Edition.

11. Marshall (1921). Microbiology. Third Edition, p. 458.

12. Reed and Reynolds (1916). Some Effects of Temperature Upon the Growth and Activity of Bacteria in Milk.

13. Roadhouse (1917). Factors of Importance in Producing Milk of Low Bacterial Count. Cir. 179, University of California Agr. Exp. Station.

14. Mortensen (1918). Factors Which Influence the Yield and Consistency of Ice Cream. Bul. 180, Iowa Agr. Exp. Station.

*15. Peterson and Tracy (1922). The Condensation Process of Preparing an Ice Cream Mix. Jr. of Dairy Science, Vol. 5, pp. 273-281.

---

*Note: The above paper appeared while this bulletin was being written.

INDEX

INDEX

A. Page
Account, current, July 1922 to June 30, 1923 26–27
Account for fiscal year ending June 30, 1923, experiment station 28
Account for fiscal year ending June 30, 1923, extension 28
Account of Michigan Agricultural College for year ending June 30, 1923 21–41
Administrative officers, list of extension division 17–18
Agricultural Engineering, report of extension work in 316–317
Allen scholarship fund, George L 24
Animal Husbandry, report of the department of 44
Animal Husbandry, report of the section of 169
Animal Pathology, report of the department of 86
Animal Pathology, report of the section of 174
Apiculture, report of extension work in 315
Applied science, report of the dean of 113

B.

Bacteriology, report of the department of 115
Bacteriology, report of the section of 177
Botanical section, report of the 210
Botany, report of the department of 117
Boys' and girls' clubs, report of extension work in 281
Bulletins of the experiment station 331

C.

Chemical section, report of the 216
Chemistry, report of the department of 119
Civil Engineering, report of the department of 60
Clothing specialist, report of 284
College inventory, summary of June 30, 1923 40–41
County agricultural agents, list of 18–20
County agricultural agents, report of 265
County club leaders 20
Current account July 1, 1922, to June 30, 1923 26–27

D.

Dairy husbandry, report of extension work in 298
Dairy husbandry, report of the department of 46
Dean of agriculture, report of the 42
Dean of engineering, report of the 58
Dean of home economics, report of the 72
Director of markets, report of the 317
Director of the experiment station, report of the 167
Distribution of special appropriations 27
Drawing and design, report of the department of 68

E.

Economics, report of the department of 120
Electrical engineering, report of the department of 63
English and modern languages, report of the department of 121
Entomology, report of extension work in 314–315
Entomology, report of the department of 124
Entomology, report of the section of 219
Experiment station account for fiscal year ending June 30, 1923 28
Experiment station, report of the secretary and treasurer 163
Extension account for fiscal year ending June 30, 1923 28
Extension specialists, list of 18
Extension work in agricultural engineering, report of 316
Extension work in poultry husbandry, report of 327
Extension work, report of the division of 261
Extension work with potatoes and vegetables, report of 307–310

F.

Faculty and other officers, list of 9–16
Farm crops, report of extension work in 293
Farm crops, report of the department of 49
Farm crops, report of the section of 236
Farm Mechanics, report of the section of 245
Farm Mechanics, report of the department of 50
First report of the board in control of athletics 157
First report of liberal arts council 156
Financial report of the athletic association 159
Forestry, report of the department of 52
Forestry, report of the section of 249

G. Page

General administrative officers 7–8
George L. Allen scholarship fund 24
George E. Lawson memorial prize 24
Griswold scholarship fund, Marilla 25

H.

Health Service, report of the department of 111
History and political science, report of the department of 145
Home economics, report of the dean of 72
Home demonstration agents, list of 20
Home demonstration work, report of the 273
Horticulture, report of the section of 250
Horticulture, report of extension work in 304
Horticulture, report of the department of 53

I.

Income of Michigan agricultural college from all outside sources from date of foundation to present time 39
Inventory, summary of college, June 30, 1922 41

L.

Landscape architecture 154
Lawson memorial prize, George E 24
Liberal arts council, first report of 156
Librarian, report of the 105
List of administrative officers of extension division 17
List of boys' and girls' club workers 20
List of county agricultural agents 18–19
List of county club leaders 20
List of extension specialists 18
List of home demonstration agents 20
List of members of faculty and other officers 9–16
List of members of state board of agriculture 5

M.

M. A. C. Association report 161
Marilla Griswold scholarship fund 25
Mathematics, report of the department of 126
Mechanical engineering, report of the department of 65
Members of station council 17
Meteorological tables 131–144
Michigan agricultural college scholarship fund 24
Military science, report of the department of 127
Muck soils, report of extension work on 312
Music, report of the department of 146

O.

Officers of instruction 9–16

P.

Physical training report of the department of 148
Physics, report of the department of 147
Positions and salaries as shown by payroll dated June 30, 1923 29–38
Poultry husbandry, report of the department of 54
Poultry section, report of the 327

R.

Registrar, report of the 100
Report of extension work in agricultural engineering 316
Report of extension work in apiculture 315
Report of extension work in dairy husbandry 298
Report of extension work in entomology 314–315
Report of extension work in farm crops 293
Report of extension work in horticulture 304
Report of extension work in land clearing 323
Report of extension work in poultry husbandry 327
Report of extension work in boys' and girls' clubs 281
Report of extension work on muck soils 312
Report of extension work with potatoes and vegetables 307–310
Report of extension work with soils 311
Report of the board in control of athletics 157
Report of the botanical section 210
Report of the chemical section 216
Report of the clothing specialist 284
Report of the dean of agriculture 42
Report of the dean of applied science 113
Report of the dean of engineering 58

Page

Report of the department of teacher training, annual 81
Report of the department of zoology and physiology 152
Report of the director of the experiment station 167
Report of the director of markets 317
Report of the division of extension work 261
Report of the division of veterinary science 83
Report of the health service 111
Report of the home demonstration work 272
Report of the horticultural section 250
Report of the household management specialist 272
Report of the librarian 105
Report of the nutrition specialist 276
Report of the poultry section 327
Report of the secretary and treasurer, experiment station 163
Report of the section of animal husbandry 169
Report of the section of animal pathology 174
Report of the section of bacteriology 177
Report of the registrar 100
Report of the section of dairy husbandry 171
Report of the section of entomology 219
Report of the section of farm crops 236
Report of the section of Farm Mechanics 245
Report of the section of forestry 249
Report of the soils department 55
Report of the soils section 252
Report of the summer session 150
Report of the upper peninsula experiment station 257
Report of the dean of home economics 72
Report of the department of animal husbandry 44
Report of the department of animal pathology 86
Report of the department of bacteriology 115
Report of the department of botany 117
Report of the department of chemistry 119
Report of the department of civil engineering 60
Report of the department of dairy husbandry 46
Report of the department of drawing and design 68
Report of the department of economics 120
Report of the department of electrical engineering 63
Report of the department of English and modern languages 121
Report of the department of entomology 124
Report of the department of farm crops 49
Report of the department of farm mechanics 50
Report of the department of forestry 52
Report of the department of history and political science 145
Report of the department of horticulture 53
Report of the department of landscape architecture 154
Report of the department of mathematics 126
Report of the department of mechanical engineering 65
Report of the department of music 146
Report of the department of physical training 148
Report of the department of physics 147
Report of the department of poultry husbandry 54
Report of the department of special courses 56
Report of the department of surgery and medicine 92
Report of the M. A. C. association 161

S

Sayer scholarship fund, William Smith 24
Secretary's financial report for the year ending June 30, 1923 21–41
Soils, department, report of the 55
Soils, report of extension work with 311
Soils section, report of the 252
Special appropriations, distribution of 27
Special appropriations for fiscal year ending June 30, 1923, statement of 23
Special bulletins of the experiment station:
  No. 117, potato culture in Michigan 333
  No. 118, pruning fruit trees 363
Special courses, report of the department of 56
State board of agriculture, members of 5
Statement of special appropriations for fiscal year ending June 30, 1923 23
Station council, members of 17
Summer session, report of the 150
Surgery and medicine, report of the department of 92

T.

Tabular exhibit of secretary's report 22
Teacher training, annual report of the department of 81
Technical bulletins of the experiment station:
  No. 57, Studies on active bases and excess acids in mineral soils 399
  No. 58, The occurrence of protozoa in plants affected with mosaic and related diseases 423
  No. 59, Flat sours 450
  No. 60, The influence of manufacturing operations on the bacterial content of ice cream 478

U.

Page

Upper peninsula, report of the 257

V.

Veterinary science, report of the division of 83

W.

William Smith Sayer scholarship fund 24

Z.

Zoology and physiology, report of the department of 152

New York Botanical Garden Library
3 5185 00259 0964